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# Public Hearings on Noise Abatement and Control Held at Boston, Massachusetts, on October 28 and 29, 1971. Volume VII

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# Public Hearings on
# NOISE ABATEMENT AND CONTROL

## Vol. VII—Physiological and Psychological Effects

Boston, Massachusetts, October 28 and 29, 1971

U.S. Environmental Protection Agency
Washington, D.C. 20460

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# Public Hearings on
# NOISE ABATEMENT AND CONTROL

## Vol. VII—Physiological and Psychological Effects

Boston, Massachusetts, October 28 and 29, 1971

Conducted by
the
Office of Noise Abatement and Control

U.S. Environmental Protection Agency
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For s [illegible] Office

# PREFACE

Under the Noise Pollution and Abatement Act of 1970 (Title IV to the Clean Air Amendment of 1970 (PL 91-604), the Environmental Protection Agency, through the Office of Noise Abatement and Control, is required to hold public hearings. A series of eight of these hearings is being conducted in selected cities to aid the office of Noise Abatement and Control in compiling information relevant to its investigation of the Problem of Noise Pollution. Further, these hearings present an opportunity for the public and industry to express their viewpoints on the general subject of noise control. The volumes in the complete series will be:

Vol. I —Noise in Construction

Vol. II —Manufacturing and Transportation Noise (Highway and Air

Vol. III —Urban Planning, Architectural Design; and Noise in the Home

Vol. IV —Standards and Measurement Methods, Legislation and Enforcement Problems

Vol. V —Agriculture and Recreational Use Noise

Vol. VI —Transportation (Rail and Other), Urban Noise Problems and Social Behavior

Vol. VII —Physiological and Psychological Effects

Vol. VIII—Technology and Economics of Noise Control; National Programs and their Relations with State and Local

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# ENVIRONMENTAL PROTECTION AGENCY

## PUBLIC HEARING ON PHYSIOLOGICAL AND PSYCHOLOGICAL EFFECTS OF NOISE

THURSDAY, OCTOBER 28, 1971

The hearing was convened at 9:15 a.m., Dr. Alvin F. Meyer, Jr., Director, Office of Noise Abatement and Control, Environmental Protection Agency, presiding as chairman.

*PANEL:*

Dr. James Botsford, Sr., Noise Control Engineer, Bethlehem Steel, Bethlehem, Pa.
Dr. Donald Eldredge, Central Institute for the Deaf, St. Louis, Mo.
Dr. Sanford Fidell, Bolt, Beranek, and Newman, Cambridge, Mass.
Dr. Henning vonGierke, Aerospace Medical Laboratory, Wright-Patterson Medical Base, Dayton, Ohio
Dr. Milton Whitcomb, National Academy of Science, Washington, D.C.

## PROCEEDINGS

Dr. MEYER. I hereby call to order this public hearing on noise abatement and control being held by the Administrator of the Environmental Protection Agency, Mr. William D. Ruckelshaus, in accordance with the instructions of the Congress contained in title IV, Public Law 91-604.

I am Dr. Alvin F. Meyer, Jr., Director of the Office of Noise Abatement and Control of the Environmental Protection Agency, and I am acting for Mr. Ruckelshaus in accordance with the instructions of the Congress.

Let me very briefly, before we get underway, state the purpose of these hearings and how we conduct them. Then we shall proceed with the business at hand.

The Congress, in title IV of Public Law 91-604, directed that the Administrator of the Environmental Protection Agency prepare a report to the President and to the Congress to be submitted not later than December 31, 1971. This report is a thorough and extensive review of the problem of noise as an environmental element in the United States, and is to include recommendations as to what should be done about the problem.

The law also prescribed that the administrator would hold a series of public hearings. These hearings are designed to provide to the Government information regarding noise in several areas: (1) Public attitudes and concern relating to the problem; (2) the capabilities of industry to deal with the problem; and (3) the views of the professions concerned with noise and acoustics as to the severity of the problem and what also may be done about it.

These hearings are national in scope. In order, however, to account for the variety of different attitudes and problems across the United States and to allow maximum public participation, they have been held at a variety of locations: Atlanta, Dallas, Denver, San Francisco, Chicago, New York, and now here.

The hearings are organized so that a specific element of the noise problem is considered at each one. They provide, as I have indicated, for public participation to the extent that the public desires to present its views on any aspect of the noise problem.

The hearing today and tomorrow is a scientific hearing dealing primarily with the problems of physiological and psychological response to noise. As I said, members of the public who desire to talk about any aspect of the noise problem will also be heard.

Now, in order to conduct the hearing in a meaningful manner, a panel of recognized experts has been convened at each of the hearings. Today I am accompanied by distinguished members of the scientific community concerned with acoustics and noise, and I shall mention them now. Dr. James Bosford, senior noise control engineer of the Bethlehem Steel Corp., Bethlehem, Pa.; Dr. Donald Eldredge, Central Institute of the Deaf, Washington University, St. Louis; Dr. Sanford Fidell, of the firm of Bolt, Beranek and Newman; Dr. Henning von Gierke, internationally known expert in this field from Aerospace Medical Research Laboratory of the U.S. Air Force at Wright-Patterson Air Force Base, Dayton, Ohio; and Dr. Milton Whitcomb, executive secretary of the National Research Council's Committee primarily concerned with noise and acoustics and vibrations problems of the National Academy of Science's National Research Institute.

Now, let me very briefly explain some of the ways we operate. This hearing is conducted according to the general rules of the field investigation activities of the Committee on Government Operations of the House of Representatives of the U.S. Congress. My distinguished panelists in effect are serving in the stead of a congressional committee and as such will listen to the witnesses and will ask questions to elicit and adduce the necessary additional information beyond that which is contained in their statements.

Under those rules obviously there are no questions permitted from the floor. If, however, a member of the audience has a comment or a question, I would ask that he write it down and hand it to a member of our staff. There are two staff members present in the audience. Mr. Kaufman, would you raise your hand,

and Mrs. Seidman. If you have a question or a comment, kindly direct it to them and they will submit the question to me. If it is a matter of general interest which should be brought into the general view, it will then be directed to the witness or panel member. If it is a specific narrow interest item, then I, as the chairman, will arrange for the person who submitted the question to either have the question answered privately by the witness or by a member of the panel.

For the information of those who are here, these hearings are transcribed verbatim. The verbatim transcript along with the submissions for the record will be reproduced by the U.S. Government Printing Office and made available to the public beginning approximately 8 weeks from now.

In addition, after they are printed, we do indeed furnish copies of the printed transcripts to the appropriate committees of the Congress so that they become part of the congressional records relating to noise.

I might comment that the material contained or produced as the result of this hearing will be utilized by the Office of Noise Abatement and Control of the Environmental Protection Agency in developing the report to Congress. It also will be utilized by us as source material in developing and implementing any legislative authorities given us by the Congress of which there are a number currently pending in both Houses.

At this point, then, I shall proceed with the business at hand. I now invite Mr. Fred Salvucci, representative of the mayor of the city of Boston, to come forward, sir, and join us at the platform. We are anxious to hear from you regarding the views of the city of Boston concerning noise problems.

Good morning, sir.

## STATEMENT OF THE HONORABLE KEVIN H. WHITE

## MAYOR, BOSTON, MASS.

## (AS READ BY FRED SALVUCCI)

Mr. **SALVUCCI.** Good morning.

First of all, I would like to apologize for the fact that Mayor White couldn't make it personally this morning. The death of his aide, John Labanard, last week has totally disrupted his schedule and I wish to apologize.

I will read his remarks if that is okay.

Dr. **MEYER.** Very good.

Mr. **SALVUCCI.** Gentlemen, I wish to thank you for allowing me this opportunity to address you.

I know that this is one of a series of hearings being held by the Environmental Protection Agency around the country to discuss community noise problems and that you came here to learn of the effects of noise on the individual. This is a recognition of and a tribute to Boston's role as a center of medical learning; but it is also a tacit recognition of the fact that the people of Boston suffer from several acute noise problems—noises of trucks and buses, construction, rail travel, and industry, which are common throughout the country, but especially the noise from the well publicized Logan Airport, which is peculiarly close to the center city and affects an unusually large number of people.

Public concern and awareness of the significance and subtlety of excessive noise is growing. Boston has tried to recognize these dangers of noise and the need for control. We have made a beginning. Mr. David Standley, the director of our Air Pollution and Noise Control Commission, will later describe our pioneering activities in this area.

As a starting point for these remarks, however, I would like to point out to you a few specifics of the problem concerning Logan Airport, which is again our most pressing problem in terms of noise. I am sure you have heard about some of our problems with the airport and some of the attempts we have made to face the noise problem. We have filed suits for the Port Authority and the airlines to help pay for soundproofing schools because the educational function in the schools, particularly in areas close to the airport—in East Boston and South Boston within the city of Boston and also in Winthrop and Chelsea outside of our boundaries—is severe.

During certain periods of the day when the wind conditions are such that overflight occurs in schools, essentially education ceases as a function. The classrooms are so disrupted that teachers have told me—I have observed this personally—essentially they give a study period because no verbal communication can effectively take place.

We have tried to address this in a stopgap measure by essentially suing for the financial capability to soundproof these schools, but obviously more long-range solutions are called for.

Let me talk about some of the other things we are trying to do. About a year and a half ago I signed an ordinance placing waste control responsibility in the capable hands of our Air Pollution Control Commission, and allocated funds for the design of an effective noise abatement program. Our objective was and is a "quieter but not silent city." I recognized that there were problems the city could not reach and that it could not go it alone. However, it is perfectly clear that without a vigorous city noise control program there will not be effective noise abatement. It is also clear that this city, any city, is hard pressed to allocate any, much less the necessary, funds for this program.

We have studied our problem. We have identified those matters of priority which we can cope with. We have drafted and our commission has approved in principle although not yet adopted several regulations. The work is proceeding and will be completed this year. Equipment has been purchased and staff authorized. But much is yet to be done.

In the quieting of our community, great benefit will be realized by major reductions in vehicle noisiness, by reduction in traffic volumes through improvement in transportation, and by planning and controlling the design and use of our streets and highways. I call for a major Federal effort in the field of vehicle noise but warn you of the dangers of restricting all powers to the central government.

What should be the role of the Federal Government vis-à-vis States and communities? Clearly, program assistance and guidance are required. Training programs, the development of standards for measurement and analysis of noise, criteria for control, research into both effects and technology are most appropriately Federal actions. Federal funds for local and State planning and control programs will serve to stimulate development of the activities necessary at those levels and support their continuation.

I would point out that in my opinion there is little to be gained, in noise abatement, from artificial stimulation of regional entities.

Performance standards for new equipment, for everything from motor vehicles to chain saws, can most effectively be established at the Federal level, and we urge that be done. We are, however, flatly opposed to a preemptive Federal authority, and in the absence of Federal standards will proceed on our own. Where the needs or wishes of a community or State for quiet can most effectively be met by performance standards which are more stringent and more restrictive than the Federal standards, then their adoption and enforcement should be permitted with proper safeguards. The burden of justification should be on the agency of government proposing the more stringent standards, of course. But those communities should not be forced, in order to meet their own community noise standards, to rely solely on onerous restrictions on the use of such equipment.

The setting of community noise standards should be entirely a local matter. We welcome guidance such as that recently provided by the Department of Housing and Urban Development, which has specified interim noise conditions for HUD-supported residential construction. We are pleased to observe that these guidelines are compatible with the standards we propose to adopt for Boston.

What relationship should be established among the Federal agencies is the second question, I think, we have to address. Many agencies have missions, responsibilities and statutory mandates which, directly or indirectly, have a significant bearing on community noise. There must be a leading Federal agency to give overall direction and provide coordination at that level. Which one? We submit the Environmental Protection Agency is the logical choice, and that it should also concern itself with occupational exposure to noise.

A catalog of principal responsibilities for the lead agency should cover several fields, including aircraft noise and airport noisiness, equipment noise, and community noisiness. This agency should be the final arbiter among Federal agencies of permissible aircraft, vehicle, and equipment noise standards and certification procedures, and should review and approve minimum standards for community noise developed for application by other agencies such as HUD. There are obvious parallels between noise and air pollution, and lessons learned in air pollution abatement should not be overlooked.

However, we urge the Congress and the Executive not to lose sight of the important differences: the manner in which sound is produced and transmitted, the sources principally responsible, the effects of the pollution.

I said at the beginning that Boston has been and is fighting Logan noise. In this we have had a significant effect, despite the city's lack of any real authority over the Port Authority or any clout with the Massachusetts Port Authority, which is the real operator and owner of Logan Airport. We have fought that authority, one of the most powerful and independent State creatures one can find. Unfortunately we have had also to fight the Federal Aviation Administration. This is one of the reasons for our recommendations above. This fight is far from won. We hope that we do not in the future have to fight the highway and motor vehicle noise by combatting the Federal agency representing those interests. But we have demonstrated we can and will fight; that we can utilize the protection of the laws and courts; that a few dedicated public servants can make a real difference.

As the Logan situation and other evidence attest, those unfortunate people affected by airport and aircraft noise, by the noise of railroads and rapid transit, by construction noise, and by factory noise, provide living testimony of the vital importance of noise control in our cities. Tomorrow you will learn more of why this is so. Today we are pleased to share our understanding with you, and to urge you forward.

Dr. MEYER. Thank you very much.

Before responding to some of the suggestions and comments regarding the relationships between Federal and State and local agencies—and we are most appreciative of your comments—are you willing for the mayor to accept a question or two from the panel?

Mr. SALVUCCI. Well, I can try it.

Dr. MEYER. It is your option, sir.

Mr. SALVUCCI. Sure.

Dr. MEYER. All right. On my left, Dr. Eldredge.

Dr. ELDREDGE. No, I don't think I have a question.

Dr. WHITCOMB. The program you outlined sounds certainly commendable. I was wondering if one of the most severe components of it is the location of the school being near the airport. How far away is that school?

Mr. SALVUCCI. Well, there are several schools in East Boston. There are three which are very badly affected. Of those three, I would say the closest is about 3,000 feet from—well, closer to 2,000 feet from the end of the runway. They are all within three-quarters of a mile of the end of the runway and within the approach pattern—those three which are most directly affected. There are probably another five which are less directly impacted, being a bit to the side, but which are still—the education function is severely interfered with.

Senator Kennedy held a noise hearing at a Barnes School in East Boston, which is one of the schools outside of the direct path and those hearings had to be constantly stopped because of the noise. And, again, that is one of the less impacted schools.

Dr. VON GIERKE. I have two questions. You mentioned recent guidance by HUD on noise levels for various activities in the cities. Have you any specific comments on these noise levels? Do they look realistic to you? And have you made an estimate what it might take to meet these guidelines?

Mr. **Salvucci**. I would like to defer that question to Mr. Standley who is going to be following. He is much more expert in those questions.

Dr. **von Gierke**. And the second question I had was: How are you planning to solve some of the problems with noise-exposed schools and other public buildings in the future? I mean what is the interrelation between your Noise Control Commission and city planning in general and standards for housing and noise control in the houses?

Mr. **Salvucci**. Okay. The point of the departure of persons is that the residential areas surrounding Logan Airport were there long before the airport and represent a major social investment in housing and community facilities to the extent that we view it as totally unfeasible and unacceptable to consider moving the people. We are interested in what kinds of improvements may come out in noise technology, but that is still in an unknown quantity so our approach has been to protect what can be protected. We now view education as a vital function that is clearly impacted by noise and which is resolvable.

The houses surrounding the airport in Boston are often wooden, and the question of soundproofing the houses is questionable because of the structure. The schools are masonry buildings. It is feasible to soundproof those buildings. We feel that that ought to be done. We feel that a part of the cost of providing air service at Logan Airport is the disruption of those children's education, and that is an unacceptable cost. So we feel that the cost of soundproofing the schools should be borne by the air traveler. The city is willing to participate in that program.

It is clear that if we soundproof those schools—we will be putting in other improvements if we are going to have a major construction contract to refurbish the high school in East Boston; it is obvious that other things should be done which are not the responsibility of the air travelers—but the sound is and we feel that that is a reasonable division responsibility.

Mr. **von Gierke**. My question was more aimed at what you propose to do to prevent similar situations in the future; if you have small airport, private airport developments, for example, in some of the suburbs, or if you have new highway projects, what planning do you propose to prevent such situations?

Mr. **Salvucci**. Okay. There are two things. To finish the point on the school noise, we have tried the legal route. We went to court and we will be going to court again we expect. However, since our first attempt at going to court, where we were essentially ruled to be in the wrong court—the Federal courts did not want jurisdiction and referred us back to the State courts.

In the interim Governor Sargent has supported the concept of soundproofing of the schools at the expense of the air industry and we are quite anxious that there is going to be followthrough on that principle, so it may be possible to achieve this without legislation. I thought it was important to recognize that fact. The Governor does have more clout with the Port Authority and we are very hopeful that that will happen.

The second thing, in terms of planning, it may sound—in terms of airports, it is our feeling that the major priority in the Boston area of intercity transportation is to develop high speed ground transportation. A third of the traffic in and out of Logan goes between Boston and New York and we feel that this is all potential to high speed rail if we had a decent service. We feel that that, at least for the short term future, really addresses the question of airport capacity. If we get the kind of high speed ground transportation that we are interested in, the question of the proliferation of a lot of small airports will not occur.

We are extremely dubious about proposals now being discussed by the FAA and the CAB of establishing several vertical takeoff and landing and short takeoff and landing airports around. So I guess the short answer to that question is: We intend to use our influence to avoid that problem by not allowing the proliferation of airports.

Likewise in the case of the highways, the city of Boston for the past year has had an official policy of being opposed to further major highway construction within Route 128 which is the circumference about 10 miles outside of the city, so again we are asking to solve the problem by not further aggravating it. That does not address the problem what do we do with the highways which have already been constructed, and that, we feel, essentially is a design problem. The highways are there, and hopefully in the Boston Metropolitan Area Transportation Restudy which is now underway we will find some approaches as to how to deal with the existing problems that we have from our existing highways.

Again, the alternative to the highways that we have been supporting—and I think there is a lot of support in the metropolitan area for it—is an improved public transportation system.

Dr. **FIDELL**. Well, I guess a comment, among other things: the city of Boston is not unique in its difficulties with airport noise. For example, Los Angeles, an area with which I am more familiar, has successfully sued itself since the agency which operates the airport in Los Angeles is not a State agency and they are indeed soundproofing the schools and closing some others and building some new ones at the airport's expense.

Also a question: What do you think, in view of the political realities are your chances for arresting control of aircraft noise from the FAA?

Mr. **SALVUCCI**. I should ask that question to you. It seems to me that the logic of the case is extremely strong. The FAA has viewed itself as an advocate agency for the airline industry, I believe, since its inception. Certainly in our experience with the FAA they have consistently acted as an advocate for the Port Authority and for the air traveler.

On our local level, with minor questions—not minor to us but perhaps minor to you, such as runway extensions, et cetera, and also on a national level, in questions like noise standards for aircraft, I think the logical case is tremendously strong and we are looking for help.

I believe the political system in this country works, and if we all work together we are going to achieve that.

I might say that just personally my job with the White administration has been to work in East Boston—the area most directly affected by the airport—and in that experience, I would say that the attitude of people in East Boston from 4 years ago to now has changed somewhat in that 4 years ago they knew they had a problem and they felt that they had no way within the system to cope with that. The previous administration of the city had supported airport expansion; the previous governor had supported airport expansion; the entire array of governmental officials had really done nothing much to address their problem, and there was a strong feeling that the only action that would get results were violent ones, and there was some not quite violent but at least major demonstrations in East Boston, and I think that today those people, in part because of their efforts—no doubt that their demonstrations helped to call attention to the problem—but I think that those people now feel that the system can work, that they have seen, you know, the mayor of this city, the mayor of Chelsea, the mayor of Revere, the governor of the State, Senator Kennedy, all of the Congressmen, line up on their side, which is a tremendous shift from 4 years ago. And I think that the major message that comes out of that is that the system can work and I hope that that message that they have gotten is not a false one and things can go an awful long way in a few years. I think we can win that if we all fight together on it.

Dr. **MEYER**. First, I again want to thank you for presenting for this hearing a very concise statement of the problem with which we must be concerned today and tomorrow. I also appreciate very much the thought that you expressed of a quieter but not silent city because I think most of us agree that sound cannot be completely eliminated out of our lives.

Let me ask you several questions if I might, sir, and if they are inappropriate and you would rather pass them to Dr. Standley why that is perfectly all right.

First, would you, for the record, mind giving us some information on the current status of the suits between the city and the Port Authority?

Mr. **SALVUCCI**. Okay. The suit between the city and the Port Authority was filed in Federal Court. The Federal Court ruled—as I understand the ruling—that they had no jurisdiction, that the basis on which the suit was filed did not apply to the city and that the suit was properly addressed to State Court.

It is now being worked on by a staff in the law department to go into State Court.

Since that occurred specifically last July, the Governor, in a major policy statement on the airport, essentially endorsed the principle of the soundproofing of the schools, and we have been in communication with the Governor's office, and we are keeping our powder dry in the sense that we have the lawyers working on the suit but we are hopeful that this can be worked out without going into the courts. We will go to court if we don't work it out the other way.

Dr. **MEYER**. Again, for the record, particularly because we are concerned at the national level in getting some orders of magnitude of the economics involved, what are the dollar values involved in this particular issue?

Mr. **Salvucci**. The school suit, I believe, was for $12 million, but I would like to emphasize that that is essentially a down payment on the problem. We do not have unlimited staff resources, so we sued for the soundproofing of schools in East Boston which are most severely affected. Not included in that suit are the schools in South Boston. Not included in that suit are any compensation for the effect of noise on the Boston City Hospital, which is also fairly badly affected. The doctors there tell me that when they are running classes the air patterns are such that the aircraft are passing overhead they have to suspend classes.

So, if you will, the East Boston school suit was a foot-in-the-door strategy to see if we could win the principle while minimizing the technical work we had to do. So that's the tip of the iceberg.

Also I would emphasize that the airport is located partly in Boston and partly in Winthrop so that the town of Winthrop has some schools which are badly affected. I believe Revere and Chelsea also do, so that the $12 million that Boston was seeking in that initial suit is really not a true measure of the economic impact. I would guess that the real problem is closer to $3 or $4 million, but that is a guess.

Dr. **Meyer**. Again, because we are interested in being sure that the record clearly indicates some facts that we need to keep in view for the future, is the Port Authority a creature of the State Government? Was it not created by the State legislature?

Mr. **Salvucci**. Yes.

Mr. **Meyer**. Or was it created by a referendum vote within the municipalities?

Mr. **Salvucci**. The Port Authority was created by the State legislature in 1956. That legislation was implemented in 1959.

Dr. **Meyer**. Another question, sir: Following up on Dr. von Gierke's line of questioning, does the city zoning and building code, at the present time, contain any provisions which are specifically associated with noise control?

Mr. **Salvucci**. I would have to pass on that to Dr. Standley.

Dr. **Meyer**. I will ask Dr. Standley that. If you don't know, it is no criticism, I would just like to have it for the record later.

One final point which I would like to make before commenting on the question of Federal preemption: I noted with considerable interest your statement regarding the relationship of high speed ground transportation to the aircraft noise problem. Obviously anything that is done here would indeed alleviate the problem at the other end or at those other terminals.

I think this is something that—I know that the Secretary of Transportation is indeed concerned about. It seems to me that you have raised an important consideration to which we must call repeatedly to the attention of our colleagues in the Department of Transportation.

I have had a question handed to me which I would like to ask you, if you have the information, and that is: About how many pupils were in those three schools that are covered by this $12 million suit?

Mr. **Salvucci**. First of all, for the record, the $12 million suit covered more than the three schools.

Dr. **Meyer**. I see.

Mr. **Salvucci**. It covered all of the East Boston schools so I believe there were 18 schools in the suit.

Dr. **Meyer**. Eighteen schools.

Mr. **Salvucci**. I would also stress that the noise estimate was an estimate—that the cost estimate for the 18 schools was an estimate and, as our estimate usually run, I suspect that they are low.

The number of pupils in the three schools that I referred to as being most severely impacted, I believe, is about—it would run between 1,500 and 2,000 students. There are two elementary schools and a high school which are directly in the approach pattern.

Dr. **Meyer**. Let me make one comment—it will also be sort of a question: We have repeatedly, of course, in our hearings around the United States heard various witnesses indicate that they are in favor of Federal standards, but they would like to see individual municipalities or other political jurisdictions still given the authority to set stricter standards particularly for vehicles. And the point that we have to make from the Federal viewpoint is that we recognize that cities and States ought to be allowed and should be allowed to establish quieter conditions within their jurisdictions than cities and states within other political jurisdictions might elect to do.

The legislation proposed both by the executive branch and the legislative branch of the Government recognizes that by reserving to the Federal Government the right to set particular source standards but reserving to the States the right to set usage standards. And I gather from your comment that you felt that there ought to be some latitude in this. Let me indicate a view and perhaps you may want to respond to it. When dealing with something like automobiles or trucks that move from State to State, one can envision some very real problems from your city's viewpoint with people who come from Connecticut, New York, Vermont, Maine, Rhode Island. If you had a law that said only vehicles operating in the city of Boston, Massachusetts' jurisdiction are those which meet a certain standard which was lower than the national standards, then one has to ask the question then: what about the truck that comes to the Port of Boston to pick up goods to be delivered to Connecticut, or comes from a plant in an adjoining State, or even within the State of Massachusetts, to deliver goods to be put aboard a vessel to be transshipped out of the port? One can immediately see several problems of interchange points being established where the truck with its trailer would come as far as, say, some peripheral point and then have to drop off the trailer, be picked up by a tractor which conformed but then would have to realize that perhaps the tires, the chassis of the trailer wouldn't conform to your standard so it would have to require offshipping and this would indeed become, then, one of the problems which has been characterized as substantial interference with interstate commerce.

Had you thought about that when you made the view that perhaps the State or the city ought to be allowed to have stricter standards? Had that consideration been given?

**Mr. Salvucci.** Yes. I believe Dr. Standley would like to address that, but I would also make a point that one thing we have learned in dealing with environmental problems in Boston is that this is an area where huge amounts of change have to come about, and these are not going to happen overnight. I think while we view the problem as a static problem, it is more logical to say let the Federal Government make standards, let those be good standards, and everyone can live with those. I think realistically some States in this country, some cities in this country have been more sensitive and more aware of the problems that are coming up, and the ability to make local standards has been crucial in the ability to bring about change.

I think the State of California—not to toot our own horn—has tended to be a groundbreaker in this way, and I believe that if we didn't have the ability for our State of California to establish and call attention to the issue in the way that you need local autonomy to do, that we have made much slower progress in all of the environmental questions but specifically in the area of noise.

But I think that it is a process problem and in our process, if we are trying to achieve an improved environment, the quickest way to that improved environment and the way that will involve the most people, which I think is also important, is to allow some local autonomy in this area, so that you can have groundbreakers. I just don't believe that the Federal Government can ever most as effectively in one fell swoop as is really necessary, and that it is necessary to allow this kind of local autonomy.

**Dr. Meyer.** Well, then, obviously there are reasonable differences of opinion on that subject. Without getting into a debate on the platform with it, I will say I appreciate your comments on this and I will ask you, if you would like to stay, we would be happy to have you observe for the Mayor. As a logical next witness we would, then, ask your Executive Director of the Boston Air Pollution Control Commission, Dr. David Standley.

Dr. Standley.

## STATEMENT OF DAVID STANDLEY, EXECUTIVE DIRECTOR, BOSTON AIR POLLUTION CONTROL COMMISSION, BOSTON, MASS.

**Mr. Standley.** Thank you, Dr. Meyer. I think that because there are people in this audience that know me, it is essential that I disabuse all of the notion that I am a doctor of any sort.

**Dr. Meyer.** All right. We will accept that disabuse.

**Mr. Standley.** I am a little surprised at Fred. He knows better.

Before getting into my formal statement, I would like to take the opportunity to respond briefly to a question that Dr. Whitcomb raised on the HUD standards. We find these standards, which are standards for guidance of the agency in approving funds and to agencies which deal with HUD-supported construction, very interesting. This principle of the allowable time for a given noise level is somewhat of a departure from previous practice. It is not the departure that the city has elected to take, but we believe the HUD standards are essentially similar to those interim standards which we are proposing to adopt. As a matter of fact, as you review later the Bolt, Beranek, and Newman report, which I will submit, you will find it has a recommended community standard, a very similar principle and level.

The effort that is going to be required to meet these standards is not yet determined. We think that by choosing interim standards, which are admittedly not good enough, we will both find out something about the effort that is required and reduce the disruption that may come about as a result.

Again, before entering the formal statement, turning to the question of vehicle standards and Dr. Meyer's questions, I want to point out that the State of California has this type of exception for air pollution control equipment and requirements. There is a safeguard in this. There was a hearing required. The State has to demonstrate the need for this, and it has to be determined feasible. And I think those are appropriate safeguards.

The State of California has long had—well, several years—has had specific requirements with respect to vehicle noise. The manufacturers have found it feasible to meet a California standard which is not a national standard. The manufacturers are finding it feasible to meet a Chicago standard which is similar to, compatible with, the California standard, and this is not creating the problems of interference with interstate commerce that are envisioned.

Now, I appreciate the problems that you bring out. Presumably if the Federal Government pushes the industry to the limits of technological feasibility, there may never be a need or desire on the part of any local agency to adopt any more stringent standards. But, on the other hand, there are local trucks; there are local vehicles; there are local motorcycles; there is local construction equipment; there is a great mass of powered equipment responsible for noise which is not interstate in character, which is sold, used and finally disposed of in the area in which it originates. And I think that, while the constitutional specter can be raised, that it is raised only with respect to a relatively small segment of the total equipment population that we are talking about. And the problems that a community faces in regulating the usage of equipment and vehicles within its bounds are formidable.

We have found this with respect to aircraft, where the legislation and the FAA standards clearly indicate that the community is to be allowed to regulate the use of these pieces of equipment, despite the fact they cannot regulate the noisiness of the equipment themselves.

The Governor made an attempt to regulate the use by submitting a piece of legislation this fall, which I am sure he will discuss. It has come to naught, and I think that is an example of the problems in regulating use. And our point is that we do not want to be stuck with only that recourse to achieving our goals.

Well, again, I will introduce myself. I am David Standley. I am Executive Director of the Boston Air Pollution Control Commission. This Commission is the principal noise abatement agency for the city. The Police Department has responsibility for enforcement of other anti-noise ordinances, such as disturbance of the peace, while the Redevelopment Authority is responsible for all planning, as in the instance of the proposed helicopter landing facility.

I will digress here and point out, in a response to another question that was asked by Dr. Eldredge, we are involved with agencies of the Federal Government, DOT specifically, in considering the feasibility of locations for new school sites with respect to the airport, and too the BRA have met and have reviewed possibilities and problems with respect to these possible sites.

Being charged by ordinance in 1970 with responsibility for adopting noise standards and regulations for noise abatement, the Commission elected first to study Boston's noise problem. The result is this document, Bolt, Beranek, and Newman, Report 2069, of March 1971, which I will submit to you, titled "Analysis of Community Noise and a Plan for Noise Control for the City of Boston Air Pollution Control Commission."

(The abve-mentioned document is on file at the Office of Noise Abatement and Control.

Mr. **Standley**. I would also submit an undated summary of that report prepared by me and titled "A Quiet, But Not a Silent Boston."

Dr. **Meyer**. The record will show that this report is included with the record following Mr. Standley's testimony.

Mr. **Standley**. Again, departing, I regret that we cannot provide more copies but the cost per copy strains our budget as it is and Federal agencies have already received some.

The limits of this report must be established. The problem of aircraft and airport noise was not considered. First, there are other studies of this problem available, both general and specific to Boston. Second, the city and therefore the Commission lack jurisdiction over aircraft noise and over the Massachusetts Port Authority, proprietor of Logan Airport.

It was our feeling that funds invested in "noise monitoring" would return fewer dividends than would investments in planning, in program design, and in selective observations and limited surveys, when accompanied by maximum utilization of existing data. Extensive field studies to attempt, first, a characterization of noise throughout the city, and, second, a ranking of its sources, therefore, were not undertaken. Some measurements were made, typical problems were evaluated, and data drawn from other surveys were utilized.

We concluded that vehicle noise is a problem throughout the city, while aircraft noise, heretofore a very serious problem in East Boston and South Boston, is becoming more and more a source of complaint in other parts of the city. Construction noise complaints are largely restricted to the central part of the city where heavy construction is now concentrated. It is apparent that the community as a whole, excluding the areas seriously disrupted by aircraft noise, is not yet as concerned about noise as it is about air and water pollution. This is in contrast to Tokyo, where despite the severity of air and water pollution problems—and they are more severe than we presently suffer from in this area—noise is the cause of more than half of citizen complaint. But the concern in Boston is growing quite steadily and the problem will most certainly get worse if corrective action is not taken soon.

Here in Boston much has been accomplished, beginning with the 1970 ordinance and the BBN study. The Air Pollution Control Commission has drafted proposed interim standards for community noise, and initial noise abatement regulations, patterned closely after the Chicago ordinance. A public hearing has been held, comments reviewed, and the regulations drafted. The redraft is now in review, and we expect to adopt the standards and some regulations in the very near future.

The Commission proposes that noise in residential areas attributable to land uses in or abutting those areas be limited to approximately 60 dB(A) in the daytime, 50 dB(A) at night and on Sundays. I would add that the word "approximately" is in there because the standard is expressed as an octave band maximum sound pressure level standard. This is dB(A) equipment. The limits would be somewhat higher with respect to another land uses, and for residential land use in industrial areas. We unfortunately have a zoning ordinance which permits residential land use in business areas and some type of residential land use in industrial areas. The maximum interim "noise allowance" set for exposure of business and recreational uses in industrial zones would be approximately 70 dB(A) in the daytime, 60 dB(A) at night.

Limits on the noisiness of new motor vehicles, construction equipment, recreational vehicles, and other powered equipment for outdoor use are proposed. These take the form of certification requirements imposed at the point of sale or lease. Under consideration are restrictions on the noisiness of new and used vehicles and equipment under conditions of use, defined as "operational restrictions." Still being reconsidered is a restriction on the noisiness of construction activities. Our feeling is that noise from this source should not exceed by more than 10–15 dB(A) the noise standard for the area in which the construction occurs.

Lastly, the framework for a system of registration of certain noise sources, permits for others, is being developed. Before the end of this year the initial set of regulations should be completed and enforcement begun. Equipment is now on hand; staff is being organized. It has been possible, to date, to allocate not more than $25,000 per year to this noise abatement activity.

In all of its deliberations, the Commission has intended to force the general application of current noise abatement technology at the earliest practicable date and thereafter to require more stringent control in order to achieve the standards currently proposed. It is our belief that the community noise standards permit a level of noise that may not be wholly acceptable to the community. We therefore designate them as "interim" standards.

Similarly, we do not believe that current control technology, as applied to vehicles and other equipment, is adequate to quiet those sources to the degree required to achieve those standards. We therefore call for certification requirements to be met by 1980 at the latest that are admittedly beyond that technology. Specifically, we recommend a certification requirement for motor vehicles of 75 dB(A), at 50 feet, to be met by 1980.

Mayor White has discussed the Federal role in noise control. I would iterate the city's conviction that Congress should charge EPA with responsibility for establishment of noise as well as air pollution standards for new and existing aircraft of all types. The FAA's role should be limited to recommendations and guidance to EPA. I would also urge EPA to take the lead in standardizing measurement, test, and certification procedures, and methods for expressing the impact of noise. Complete Federal preemption of the standard-setting process is, however, unnecessarily restrictive of the right and opportunity for communities to achieve the environmental quality they wish. That lesson has been too painfully learned from the aircraft noise problem.

Thank you for the opportunity to appear before you.

If I can discuss any further the regulations which the Commission proposes to adopt—and I can provide a draft copy for your guidance at this time. I would prefer that it not be a part of the formal record since these have not been adopted but are under consideration.

I would like also to point out the results of a neighborhood poll about airport noise which show the concern as very serious. Ranging from 83 percent of the sample population in East Boston to 6 percent in the Hyke Park section—well separated from the airport—this would illustrate the disparity in level of concern of our area.

Thank you.

Dr. **Meyer**. I would like to have that one for the record—that poll—if we could have that for the record, unless you have some objections.

Mr. **Standley**. I have no objections to this. It is not in the form which I would normally submit things for the record. So let me, for the record, cite the source. The Boston Globe, during the period of August 16 to September 6 of this year, published the results of a number of neighborhood polls taken by the Becker Research Corporation. This is an abstract and summary of certain aspects of those newspaper presentations.

Dr. **Meyer**. Very good.

If we might also, Mr. Standley, without including it in the record, but for staff use and for members of the panel who would have an interest in this, I would like to get the copy that you volunteered and proposed—

Mr. **Standley**. I would certainly leave it and at such time—and this I expect to be in the very near future—the Commission does actually adopt regulations, we will certainly take the opportunity of submitting copies of those for the formal record.

Dr. **Meyer**. Fine. I would appreciate that.

Before I ask any questions, I will again ask the panel, starting on my extreme right—

**Dr. Botsford.** I was interested to hear that you are proposing your standards in terms of octave bands rather than A-rated sound levels.

**Mr. Standley.** For the community—what we call "community noise standards," these are restrictions on allowable noisiness at the lot lines or at lot boundaries attributable to land uses within the zones.

**Dr. Botsford.** Yes. Well, I believe Chicago did that more than 20 years ago, and they have gone from octave band to dB(A) in their current ordinance now. I was just curious why you were starting with octave bands when dB(A) seems to be preferred.

**Mr. Standley.** Well, I guess the simplest answer to that question is that this is the recommendation of the consultant, Bolt, Beranek, and Newman, which we had no basis to challenge. We do include, for the purpose of preliminary survey and monitoring a dB(A) equivalent to these octave band analyses.

The other objective is to accommodate the problem of pure tones, which in our limited experience with industrial and other noise sources can represent a problem and result in a source of community annoyance even though the dB(A) equivalent is not exceeded.

I think this was found some years ago when the fanjet came into being and all of a sudden a dB(A) approach to aircraft noise was not feasible.

**Dr. Fidell.** I guess I have two questions. First of all: What sort of teeth do you have in your proposed regulations to provide voluntary compliance as opposed to enforcement and in particular with respect to stationary sources such as loud industrial operations. Do your regulations have anything to say?

**Mr. Standley.** The enforcement question—we derive our authority from the general laws.

**Dr. Fidell.** A general nuisance law?

**Mr. Standley.** No, Chapter 40 of the general laws describes a number of municipal powers, including the grant of authority to cities to regulate noise from whatever source. Chapter 40 also provides for maximum penalty for violations of those regulations that may be adopted under it, and this happens to be $50.

So that enforcement authority has been passed on to us by the City Council.

Now, we recognize this is a totally inadequate level of enforcement, and one of our objectives is to, in effect, modernize Chapter 40 of the general laws to provide for an adequate level of enforcement. There is, however, another possibility here. The State Department of Public Health has chosen to regard noise as an air pollutant. There is little, if any, support for this view in the general laws in my opinion, but that is not a legal opinion because neither do I have a degree in law.

However, if that view can be supported and holds, then the enforcement procedures for air pollution control come into play and there is then a maximum penalty of $500 per violation plus injunctive authority. In addition, one of our continuing objectives is to amend the Boston Zoning Code, which has a host of references to noise, which you will find appearing in part of this report, and bring those references into line with our regulations.

The Boston Zoning Code is a rather effective enforcement tool for planning and design at least.

Now, as to the question of stationary sources, it is our intent that the community noise standards set for land uses and relating to the noise crossing the lock in question will serve to impose controls on industrial noise sources. That is one of the very specific intents.

We have not attempted, at this point, to regulate what I will describe as intraindustrial noise. If an industrial operation is producing noise which is affecting another industrial operation in the same zoning district, then the regulations are silent at this point in time.

Dr. **FIDELL.** My other point: To take somewhat pedantic exception to your point, your implication at least that the requirements of 75 dB(A) for vehicles is technologically not feasible, I don't believe that is the case. I believe it is the case of who is going to pay for it. I mean the physics of noise control is fairly well understood and there is nothing exceptional about making a vehicle that quiet.

Mr. **STANDLEY.** Well, in response to that, I can only cite the arguments that have been made by the motor vehicle representatives to the Commission at and subsequent to the hearing which we held on September 27, the same day that you people, I believe, had your show in California.

The manufacturers make several points about the sources of noise of vehicles and the impact of things such as the Federal safety standards for tires and brakes which, in their view, render the achievement of 75 dB(A) by 1980 a serious question.

We, as a Commission, will probably delete the 1980 specific requirement for 75 dB(A) at 50 feet under certification conditions, which is approximately 30 miles an hour and maximum acceleration. This is not to say that we do not believe this is a desirable objective. It is to say that we feel on a rather shaky ground in adopting it as a regulation at this time.

Dr. **VON GIERKE.** Coming back to the question of the hot circle and the interim noise allowance you set for your various areas in the city, you plan to achieve these levels by control at the source alone?

Mr. **STANDLEY.** Yes.

Dr. **VON GIERKE.** And your enforcement is directed at the source alone.

Mr. **STANDLEY.** That is correct.

Dr. **VON GIERKE.** And my question is: Are there any plans to incorporate these levels into future planning of housing developments and street traffic, etc.?

Mr. **STANDLEY.** Well, I think—

Dr. **VON GIERKE.** Excuse me. The overall background level usually is not determined by the original noise sources but by the overall background noise, by the total exposure during the day and night.

Mr. **STANDLEY.** I think by the very fact of their adoption, they will be incorporated into the planning process. The BRA—the Boston Redevelopment Authority—is the city's planning agency, and we have already begun to work with that agency.

As I said, we are working now toward modifications of the zoning ordinance which the Boston Redevelopment Authority, in effect, enforces.

The question of the impact of transportation and transportation planning on noise in the city is one that I think must be delayed or deferred until such time as the transportation planning review, which Mr. Salvucci had reference to, completes its work, and we have better idea of what transportation in and out of and through the city is going to amount to, is going to be like.

Dr. **VON GIERKE**. Are there any plans or considerations to have operation restriction of some traffic or other noise sources? For example, I mean eliminate trucks during certain hours of the night on certain streets and roads, or restrict lawn mower activity during certain hours of the day.

Mr. **STANDLEY**. Yes, sir. There are operational restrictions under consideration to the extent that my Commission has directed me to produce a draft regulation before the end of the year which would incorporate such restrictions.

Dr. **WHITCOMB**. I would like to belabor the point of vehicle certification by 1980 just a little bit further. You mentioned the problem of tires being eliminated for trucks, yet you are measuring at 30 miles an hour, and I presume most of the truck traffic in the city will be at that speed or less maybe.

Mr. **STANDLEY**. Yes, sir.

Dr. **WHITCOMB**. At that point, tire noise shouldn't be a problem. It is only when you reach speeds of 60 or 70 miles an hour that tire noise begins to take over beyond the engine noise.

Mr. **STANDLEY**. There has been some evidence, which I did not bring with me, submitted by the vehicle manufacturers, which would indicate that under the certification conditions, tire noise from present tires would be the blocking—

Dr. **WHITCOMB**. Even at 30.

Mr. **STANDLEY**.—problem. Yes.

And I cannot, at this point, attest to the validity of that statement, and neither do I have any understanding of the effect of the new Federal safety standard on any aspect of motor vehicle noise.

Dr. **ELDREDGE**. You have raised the point that local areas ought to be able to perhaps do a little better than their neighbors, if they so desire, and I wonder if in order to achieve an appropriate mix of such local control and also some national uniformity in communication about noise standards, if you would find it useful to have sets of standards—for example, vehicles of Standard A, Standard B, Standard C—which were graded in such a way that you could for a particular location, or hour, operation, what-not, say this is approved for Standard A all of the time; Standard B, such and such hours; Standard C only on special permit. In other words, have something like that which, then, everybody in the country would know about and you could regulate accordingly with flexibility appropriate to the time and place.

Mr. **STANDLEY**. That is a proposition which has never been discussed in my presence before, and one which strikes me as interesting and of sufficient impact that I probably should not respond off the cuff.

Dr. **MEYER**. Any other question now, Dr. Eldredge?

Dr. **ELDREDGE**. No.

Dr. **MEYER**. I have several, sir, if I might.

First, I noted in your testimony that the problem of aircraft and airport noise was not considered because the Commission lacked jurisdiction over aircraft noise.

Does the report consider the noise from your elevator and subway system?

Mr. **STANDLEY**. Yes, sir, it does.

Dr. **MEYER**. It does.

Mr. **STANDLEY**. It makes mention of that, and it is our belief that that noise is subject to our jurisdiction. We have not been challenged by the Mass. Bay Transportation Authority on that point. They have inquired as to whether we think they are subject to our jurisdiction, and they have not indicated that they disagree.

Dr. **MEYER**. Your Commission, then, plans some rules and regulations regarding noise associated with their operation?

Mr. **STANDLEY**. Yes, sir.

Dr. **MEYER**. Both internal in the car where the passenger must ride for some period of time and external to the system?

Mr. **STANDLEY**. We have not yet concerned ourselves, save for an attempt to do some measurement, with the problem of the passenger. As a passenger, I can attest to the fact there is a problem. But we have not given any consideration at this point to whether we have any authority and if so how we would implement that authority.

Dr. **MEYER**. I see. If you know it, what is the typical commuter's time aboard the system?

Mr. **STANDLEY**. I don't have that data with me.

Dr. **MEYER**. There was a point that was raised in some of our other hearings as to the cumulative exposure of people who come from the suburb or outlying areas or even inside the city to another point, and then pass construction sites and are there exposed to noise.

Mr. **STANDLEY**. I can try to get that data for you.

Dr. **MEYER**. It would be useful to us as part of our information-gathering.

Another observation, before asking a couple questions: I gather from your testimony what has been underlying some of the testimony we have been receiving elsewhere regarding Federal action and preemption; that is that you are worried about the historical situation with regard to aircraft noise. Is this underlying your testimony?

Mr. **STANDLEY**. I think we have also been impressed by the problems with motor vehicle control, with the role of the Federal Government here.

I think the action of the Congress in demanding a reduction to— a rather specific reduction, in a rather specific period of time, is one which has moved the Federal bureaucracy forward at a much faster rate than it might not otherwise have done. I think that movement was essential and I think it is important not to have to rely on a similar action by the Congress in the noise field.

Dr. **MEYER**. Let me follow this line of questioning a little bit more with you if I might.

You envision that it would be desireable for a city to be allowed to set standards more restrictive than, say, Federal standards. Would you envision that this would be a feasible procedure given the fact that there are or would be few or relatively few vehicles from outside the city that are within its jurisdiction. That is, if you controlled the sale of all the vehicles to meet your standards or all items of equipment to meet your standards, wouldn't you deal substantially with the total problem that you are responsible for?

Mr. STANDLEY. I think if you substituted the word "state" for the word "city" in that question, I would concur.

We recognize in an attempt to regulate as a city, and in terms of land area of a small city, that we have a serious problem with equipment which is purchased outside of the city and subsequently used within its bounds, and this is one of the reasons for wishing to extend the current proposal to a use regulation in addition to a sale or lease situation.

The city's basic point on standards is that it ought to be in a position to determine the degree of quiet it wants within its environs. It should then be free to follow all reasonable courses to achieve that degree of quiet, and certainly it ought to focus on elements which are logically within its control. And it ought to extend, then, its activities to the regulation of use of elements for which standard-setting may be most effectively a Federal responsibility.

But, in the final analysis, if its desires for quiet cannot be met by that sort of proceeding, I think it ought not to be barred from taking the next step which is establishing standards for the performance of new equipment or used equipment.

Dr. MEYER. In that approach, you would then envision that you would have penalties for the sale within the city of items which did not meet that standard.

Mr. STANDLEY. That is right, and penalties for the use within the city of the provides which did not meet that standard.

Dr. MEYER. You would, then, require some change in the law, because I think you said something about a maximum of a $50 fine—

Mr. STANDLEY. Yes.

Dr. MEYER.—which isn't much of a deterrent.

Mr. STANDLEY. That is right. Well, it is for a lawn mower, but it is not for a tractor-trailer.

Dr. MEYER. You say the proposed Federal law would provide for Federal standards which would make it a Federal civil offense with fines up to $25,000 for each offense, each day constituted a separate offense for the introduction into interstate commerce by a manufacturer of an item which did not meet the Federal standard.

I note that you have a budget of about $25,000 per year to enforce your noise program now. It would seem to me that both of our desireable ends of producing products which meet a standard, which hopefully would be the best standard that could possibly be developed, would be better provided for by bringing the massive weight of the Federal Government to bear on the manufacturer with very stiff penalties for violation. Also this—

Mr. **Standley**. I hope there is no question, Dr. Meyer, of the eagerness on the part of the city of Boston to see a Federal standard, and an effective Federal standard well enforced. I think this is a cornerstone of our testimony here today.

Dr. **Meyer**. Yes.

Mr. **Standley**. We are just trying to avoid the preemption clause and that is all. We recognize that you have considerably greater authority, can bring much more pressure to bear generally, and probably are better equipped to ferret out violations. We simply do not want to be excluded in the final analysis from determining our own destiny.

With respect to our budget, we are quite hopeful that the Congress will see fit to provide for program assistance on the part of the Federal Government, and we certainly hope that the fact that we and others have stepped forward early in the game and spent money and continue to spend money does not preclude us from receiving assistance on the basis of that expenditure.

Dr. **Meyer**. Let me respond to that for the record and also for the participants who are here—and I consider everybody in the room a participant in the hearing—the legislation now pending provides for a technical assistance program to the States and any political subdivisions which would include major cities and counties as well. Such assistance would be in the areas of enforcement and all other activities of noise control.

There is an interesting provision with which maybe you are unfamiliar. This states that if the Federal procedures are enacted, the Federal Government may—somewhat analagous to the provisions of the Air Pollution Control Law—delegate, by agreement with the States, enforcement authority to the States. Thereupon, 50 percent of any fine then accrue to the State or to the political subdivision to which it is delegated.

Mr. **Standley**. Is there a provision in this legislation for program grant assistance?

Dr. **Meyer**. Technical assistance defined as broadly as we have presented it in our testimony to the Congress may range from helping get the program started to providing equipment and education. It is a rather broad-gauged assistance program rather than the typical categorical grant program to which I think you are referring.

Mr. **Standley**. However, as I listen carefully to your remarks I do not hear you saying that the Federal Government will provide funds to the communities to operate programs.

Dr. **Meyer**. It may provide funds, under this technical assistance provision, to operate programs for a limited period of time.

Mr. **Standley**. This is not analgous to the current program grant—

Dr. **Meyer**. No.

Mr. **Standley**.—grant program which is available under the air pollution legislation.

Dr. **Meyer**. This is not.

Mr. **Standley**. I think it should be. I would make a strong representation on that point.

Dr. **Meyer.** Right.

Let me respond very briefly to two questions which are germane to this, which have been handed to me. The first relates to the question that has been raised by Dr. von Gierke several times about planning. It has to do with one of the requirements relating to noise environmental impact statements.

Under the existing section 102(2)(c) of Public Law 91-190, projects involving Federal monies are required to file environmental impact statements, as you know. And we are now aggressively following the examination of the question of noise impact associated with these.

We would expect, of course, the municipalities, through the municipal clearing houses, to be sure that the citizens are informed of proposed throughways and things which Federal monies are involved so that their views on the subject can be included. And we very carefully look for this, I might add. So I would hope that your programs would take that into account.

Partly germane to this discussion is the question: What are EPA's requirements in the legislation? I have already discussed some of them.

Very briefly, legislation pending in the Congress provides for the Environmental Protection Agency to establish standards for vehicles, construction equipment, other internal combustion-powered equipment, to provide technical assistance to the States, to undertake a broad research program for fulfilling later requirements and to serve as a focal point for activity in the Federal Government with regard to noise.

I thank you very much, sir, for giving us a free expression of your views, and we look forward to working with the city of Boston and the State of Massachusetts, as we do with all large metropolitan areas in the other States. Your comments will be very useful to use in structuring our program, sir.

Mr. **Standley.** Thank you.

(Mr. Standley's report, "A Quiet But Not Silent Boston," follows.)

### INTRODUCTION

Noise in the City of Boston, and what to do about it, are the subjects of a recent report by the consultant firm of Bolt, Beranek, and Newman, Inc. (BBN) under a Boston Air Pollution Control Commission contract. As a result of this report, the Commission plans to hold conferences and public hearings to consider (1) the setting and achievement of standards for community noise levels, and (2) the proposal adoption of regulations and implementation procedures to restrict excessive noise. Sensitive equipment for noise measurement has been ordered and the necessary additional personnel will be added to the Commission's staff in the near future.

The Boston Commission was charged with jurisdiction to investigate, control and abate noise in the City of Boston in April, 1970. Thus, Boston became the first New England city to recognize the serious nature of both background noise levels and excessive noise created by temporary activities. By acting on the recommendations of the BBN report regarding proposed regulatory programs accompanied by the setting of community noise levels, we hope to be able to reach the goal Mayor Kevin White set for us in April, 1970—"A *quiet*, but not a silent Boston. . ."

### REPORT FINDINGS

The Commission's consultant, in comparing results from interviews, determined that Bostonians consider their neighborhoods to be noisier and judge neighborhood noise levels to be of greater intensity than do residents

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BECKER NEIGHBORHOOD POLLS - NOISE FROM AIRPORT

| Neighborhood | % - Very serious | Rank in Order |
|---|---|---|
| East Boston | 83 | 1 |
| Hyde Park | 6 | 21 |
| South Boston | 50 | 5 |
| Jamaica Plain | 17 | 20 |
| Central Boston | 8 | 21 |
| West Roxbury-Roslindale | 9 | 20 |
| Charlestown | 27 | 14 |
| Roxbury | 9 | 21 |
| Dorchester | 24 | 18 |
| Allston-Brighton | 10 | 20 |

in Boston's suburbs, in Detroit, or in Los Angeles. Aircraft, motor vehicles, construction activities, and industrial operations are among the noise sources cited most frequently by Boston residents.

Noise levels were monitored at construction and industrial sites, and at a downtown location of consistently heavy traffic. In every instance, the consultant measured substantially higher noise levels than are generally considered acceptable, based on technological and practical improvements already available for noise control. We believe that a vigorous noise control program, using currently available techniques, would achieve a significant reduction in a reasonable period of time.

The effects of noise are extensively discussed in the BBN report and a comparison of various existing and proposed noise criteria and standards is made. It is also noted that the City of Boston is preempted from regulating the noisiness of aircraft and also of recreational motor vehicles such as snowmobiles.

The BBN report suggests certain interim and future community noise levels as being both necessary and practical. (For more information on noise pollution and decibel measurement, please see attached Audubon booklet.)

BBN has recommended interim noise standards to be applied to single sources of noise as measured at property lines or zoning boundaries. These levels are judged to be achievable in the near future, without any need for any "scientific breakthroughs".

1. Standards for noise at lot-lines or zoning district boundaries:

| | |
|---|---|
| Residential | 55 dB(A) |
| Business | 62 dB(A) |

2. Where general industrial districts abut these zones, the noise limits would be raised to:

### RECOMMENDATIONS

| | |
|---|---|
| Industrial/Residential boundary | 61 db(A) |
| Industrial/Business boundary | 66 dB(A) |

It is felt that application of such regulations would ensure that general noise levels in residential areas would not exceed 60 dB(A); in business and industrial areas, 70 dB(A). BBN suggests these levels would be acceptable at this time, although it is recognized that such areas might still be considered as noisier than is desirable.

Construction noise is treated separately in the report, on the basis that construction is necessarily somewhat noisy, and is a temporary problem in any location; but, nevertheless, such noise can and should be controlled. The recommended limits for noise in the vicinity of construction sites are, for sites in the several types of zoning districts:

| | |
|---|---|
| Residential | 75 dB(A) |
| Business | |
| Restricted Manufacturing | 80 dB(A) |
| Waterfront Industrial | |
| General Industrial | 85 dB(A) |

(BBN suggests that instead of prohibiting nighttime construction activity, a stringent and, in most cases, prohibitive noise limit of 45 dB(A) be set for all zoning districts except general industrial, wherein the nighttime noise limit would be 75 dB(A).)

Motor vehicles are clearly a major source of noise in the downtown area, near highways, and even in residential areas. The report contains recommendations for limits to be imposed on the maximum noise that could be emitted by new cars, trucks, buses, and motorcycles, with the manufacturers being required to certify compliance. The initial limits (retroactive to 1968 and 1970 respectively in the cases of heavy motor vehicles and motorcycles) would gradually be made more stringent over the period 1973 to 1980. The 1980 limit would be a maximum noise level of 75 dB(A), fifty feet away from any new vehicle.

In a similar manner, restrictions are proposed to deal with excessive noise from new self-powered construction, commercial, and domestic equipment. This type of equipment would include compressors, tractors, chain saws, lawn mowers, and many other items.

Other BBN recommendations deal with the operation of the Commission's noise control program: personnel requirements and qualifications, noise measurement equipment, administrative procedures, and possible changes in city ordinances and regulations.

### CONCLUSION

The Commission has reviewed this report and releases this summary for general discussion. We believe that the recommendations made by Bolt, Beranek, and Newman, Inc. are sound and equitable. Some differences of opinion regarding the problem of noise pollution and its control will doubtless arise. We feel, however, that it is as important to control excessive noise as it is to reduce and eliminate the pollution of the air, water, and land. While we are primarily concerned with the impact of excessive noise upon human physical and mental well-being, we are also hopeful that control of noise will lead to a significant improvement in the quality of life in the City of Boston. The prompt implementation of these recommendations is the best start toward the objective of a quieter city.

Complete copies of the bolt, Beranek, and Newman, Inc. report, "Analysis of Community Noise and A Plan for Noise Control for City of Boston Air Pollution Control Commission" are available for review at the Commission's offices. Due to the limited number of copies, we are unable at this time to provide for general distribution of the complete report.

Dr. MEYER. Now, we have heard from the city in which we are located. I would now like to as Mr. Guy Rosmarin, representing Governor Sargent, if he would like to give us the State administration's views on this program.

Glad you are here, sir.

## STATEMENT OF THE HONORABLE FRANCIS W. SARGENT, GOVERNOR, STATE OF MASSACHUSETTS, (AS READ BY GUY D. ROSMARIN)

Mr. ROSMARIN. Dr. Meyer, distinguished members of the EPA panel. On behalf of Governor Sargent I would like to welcome you to Massachusetts. It is our hope that your hearings today and tomorrow will be very productive.

The Governor sends his regrets that he cannot be here today but has asked me to come here today and to deliver to you his remarks to this hearing.

Dr. Meyer and distinguished panel. I would like to thank you for the opportunity to testify before this panel on the subject of noise pollution.

In recent years we have witnessed substantial public concern for environmental problems and these concerns are often echoed by the enactment and implementation of far-reaching programs and policies. Yet we have largely overlooked the problems of noise pollution—a problem which probably has as much direct effect upon people as any other pollutant.

The Massachusetts Audubon Society has stated that the average noise level of city traffic in Boston measured in school playgrounds during the morning hours is 78 decibels. Altogether, noise levels in our urban areas have grown 800 percent since 1956.

One of the reasons that noise has not captured the public's attention to the extent of other categories of pollutants is that, by its essential nature, it is a localized problem. Few people are exposed to the same source of noise at the same time, thus making it difficult to generate the necessary political pressure to achieve direct remedial action. Still, the problem of noise pollution is growing and with it public concern. We cannot afford to ignore it any longer.

Perhaps the most critical of our noise problems is that of airport noise. If you want a clear definition of this problem, I urge you to go over to the neighborhoods surrounding Logan International Airport; spend an hour listening to the planes landing and taking off. When you leave, remember that the noise levels you have just heard are those that these people must live with day-in and day-out, 12 months a year. That experience will probably be of as much value to you than the testimony that you will be hearing today. It is these citizens who must pay the unwritten costs of aviation noise, costs which include loss of sleep, nervous disorders, constant aggravation, and substantial loss of property value. It is these people whom we must consider.

I have already taken specific actions to do something about this problem.

I requested that the Massachusetts Port Authority withdraw its application to construct an additional parallel runway at Logan. This request was honored.

I filed legislation which would allow airport proprietors to establish rules and regulations for the reduction of airport noise in our State.

I have actively supported legislation filed in the Congress by Senator Edward Brooke to establish a Federal program to retrofit existing aircraft with equipment to decrease noise levels, or phase out existing aircraft by means of Federal tax exempts.

Yet, the Commonwealth of Massachusetts cannot solve this problem alone. We need Federal help.

In 1968, Congress passed Public Law 90–411, which amended the Federal Aviation Act of 1958 and gave the Federal Aviation Administration the responsibility to establish and enforce regulations to control aircraft noise. The FAA also has the authority and the responsibility to develop programs to protect people living in the vicinity of aviation noise. However, the FAA has other responsibilities, including the promotion of aviation; and to date, these responsibilities have had a higher priority than noise abatement.

Therefore, I urge you to recommend to Congress that the responsibility to set ground level aviation noise standards be given to the Environmental Protection Agency and that a statutory mechanism for close cooperation between the FAA and EPA be developed. This problem will never receive its proper priority unless it is made the joint responsibility of an agency whose fundamental mandate is to protect our environment.

Although I believe that airport noise is the most serious noise problem we confront today, it is by no means the only one. Urban noise alone is doubling every 10 years and the evidence of its threat to body and mind is growing concurrently. We live in an era dominated by the machine.

Yet, we do not have to live with this type of noise. Modern technology, with such devices as mufflers, plastic pipes, and vibration-damping equipment, can decrease noise levels appreciably. If motels with modern soundproofing equipment can be built next to airports, there is no reason that similar equipment cannot be used in schools, hospitals, and other buildings in areas of high noise levels.

Therefore, I urge your consideration of the following, in your deliberations:

1. National performance standards that must be met by all manufacturers before they can sell equipment that produces or has the potential of producing noise levels above 60 decibels.
2. The establishment of time schedules for meeting these noise abatement standards, such those that have been set up for the automotive industry for the control of automobile pollution.
3. A program of tax incentives for certain manufacturers who voluntarily improve existing equipment for the purpose of lowering noise levels.
4. National guidelines for the regulation of community noise criteria with the provision that States may in certain instances promulgate more stringent regulations provided that the State can demonstrate the need for these regulations.

It is only with this type of a strong Federal commitment that we will be able to confront these problems.

In the next few years, the level of noise will continue to increase unless we take remedial action now. States cannot be expected to act unilaterally; they must have Federal support and guidance. The Environmental Protection Agency has been given an opportunity to give the States this support and guidance and I urge you to seize it and develop a comprehensive noise pollution abatement program.

Thank you for the opportunity to testify before you today.

Dr. **MEYER**. Thank you for bringing the Governor's views. I will respond before asking if you have any desire to respond to any questions. Today that is purely up to you since the Governor isn't here.

The agency which I represent takes very seriously the opportunity which it does have. I wish to reflect to the Governor and his staff that we intend to very vigorously execute whatever authorities that the Congress might give us under pending legislation and follow through with any existing authorities we now have. The Assistant Administrator of the agency, Mr. Thomas Carroll, in New York, quiet succinctly stated this the other day. I can assure you from my viewpoint that I know Mr. Ruckelshaus is deeply concerned that we accept these responsibilities.

Obviously whatever the Congress does about pending legislation and relationships with the FAA and ourselves is a matter for the Congress to decide. We strongly presented our position with regard to the administration's proposal which would have given us effective veto power. What is going to happen to that we really don't know at this point.

We would, of course, attempt to implement vigorously, as I have said, whatever authorities we do get. And if they are not adequate, based on our observations and those of governors, and cities, and citizens, then we are going to go back to the Congress and ask for other help.

Would you be willing to accept any questions?

Mr. **ROSMARIN**. I certainly would.

Dr. MEYER. All right, fine.

I will start off on the left then. Do you have any question or comment?

Dr. ELDREDGE. Yes. I am curious as to how someone arrived at the figure 800 percent growth in noise since 1956. What were the dimensions that went into such a figure?

Mr. ROSMARIN. Well, we have reviewed some of the existing levels of noise as have been measured by some of our agencies. And based on our discussions with Our Department of Public Health, it was the feeling, based on this evidence, that noise had dramatically increased in the last several years.

Now, I want to emphasize, of course, that computed into this estimate of an increase in noise is, of course, all sources of noise pollution.

For example, in 1956, from which date the figure was calculated, jet aircraft had not yet made their entry onto the urban scene. Secondly, we have one of the closest aviation facilities in the country in terms of Logan International Airport.

In many cases, that is a blessing, and in other cases, in terms of computing what we estimate to be the increase in noise experienced by our metropolitan population, it is a very severe problem. So I would not want to say to you, Dr. Eldredge, that it is a precise computation but as best we are able to calculate this represents the increase in the levels of noise as preceived by the metropolitan population in the last 15 years.

Dr. ELDREDGE. Thank you.

Dr. WHITCOMB. I also had the same question in mind, and I think the reason Dr. Eldredge and I are jumping on the 800 percent increase is certainly not to embarrass you, but intuitively we would probably agree and estimates would likely give you the impression of doubling every 10 years, or whatever the estimate might be. But we are trying our best to, at this point, document some of these things, and we are embarrassed to find that rarely has somebody been in a neighborhood or an area with equipment in a certain measuring scheme 10 years before, and then again go out 10 years later. And so we were sort of hopeful that you might have data here.

Mr. ROSMARIN. I would say that we would be glad to provide for you the data upon which this figure was calculated.

In the last year and a half we have turned our attention to this problem largely because of the problem of aviation noise. We have tried to consider that separately. We have found that we must address that problem separately. But we must consider it within the context of the overall noise levels. Traffic computation figures also give us some idea in terms of the decibel levels that certain urban populations experience today.

Other areas that we measure, of course, include some of the material that Mr. Standley has provided for you already. But, as I say, I would be glad to submit this data for you.

I don't pretend that it is the most exact data, but on the basis of accrued evidence before us, we calculate this since 1956 to be approximately at this level.

For example, if I could just embellish upon it for a moment, before we get to the area of aviation noise, the Port Authority has a very systematic approach to documenting complaints, as do we. We are beginning to get into this field. The legislation that the Governor submitted called for the creation of a State Office of Noise Abatement with a fulltime director. And while Mr. Standley indicated it came to naught this year, we have every expectation that within the next year or so that the legislature will agree with us that there is a need for this kind of State Office of Noise Abatement Control to develop these kinds of programs. But because we are getting into this area, we are finding that the complaints are coming from geographic areas as far away as 40, 50 miles away. People who never experienced noise, per se, suddenly find that they are calling to complain—we have city and town officials calling us 30, 40 miles away. But nevertheless I would be glad to provide you with this data.

Dr. **Meyer.** I think it would be useful because we are trying to get orders of magnitude estimates of the problem and they vary with different people, but that doesn't mean they are necessarily inaccurate. As long as you know how they were based, why, they are very useful. I would appreciate if you can provide that for the record.

Mr. **Rosmarin.** Be glad to.

Dr. **Meyer.** Dr. von Gierke.

Dr. **von Gierke.** I have a somewhat embarrassing question or statement. In my opinion, sir, technology to predict what aircraft noise exposure would do to people and what public response you would expect from aircraft noise was available 15 years ago. The situation we got ourselves into with our major airports was clearly predictable and predicted at the time we introduced the jet aircraft operation, and my first question is: Has any study been done 15 years ago, 10 years ago, and so on, to answer this question?

Mr. **Rosmarin.** Of course, I wouldn't be able to tell you whether any studies were done. I think that, in terms of the history of Massachusetts, I would say probably not at the State level. You have to understand that our State is now organizing itself very much along the Federal lines. We have just created a Department of Transportation 4 months ago, whereas, the Federal Government has had a structure at least for the last 3 or 4 years, and certainly since the last major Federal administrative change 15 years ago, in the Truman administration. So that when we talk about what happened 15 years ago in Massachusetts, I think, if I could describe the situation to you in this way, doctor, that it would be the following: We had, at that time, an aviation facility. It was running into serious problems of financing, and, at that time, our State legislature made a decision that the best way of providing for the growth of aviation in this State would be to create an independent authority to promote the growth of aviation along independent business lines.

We created a Port Authority, which has been a model of efficiency and businesslike practices. It is suddenly, in the last decade, that we are waking up to the fact that, while we have a very active aviation facility, it is not without its problems, and that the State has a definite responsibility to its citizens who must bear some of the problems inherent in such a facility's operations, to govern those operations. And right now we are discussing very carefully how we can solve these pressing problems.

Dr. **von Gierke**. I guess you are in the same situation all airports in this country are. It is not that you are an exception.

But my point is that most of the things we hear today as solutions are short-range solutions which might not really bring the desired results.

Mr. **Rosmarin**. In terms of aviation noise?

Dr. **von Gierke**. In terms of aviation noise and other noises. As I indicated before—I mean you might restrict the truck noise output at the source as much as you want. If you don't have parallel with this adequate zoning and housing planning, it doesn't help you a thing. It is the same way with all of the programs on retrofit of aircraft, and changing of operation patterns. It will change the situation for a certain percentage of the population which lives farther away from the airport, but the ones very close by will always be exposed unless you have some long-range planning which really eliminates residential housing in noise-exposed zones.

Now, I am sure you are aware of the program of DOT and HUD, where the Logan Airport was singled out for a detailed study of projection of noise exposure for the next 10 or 15 years to study what retrofit of aircraft would bring in terms of total noise exposure, and what land use recommendations would help to solve the problem.

Have you anybody within Massachusetts which attacks this problem of how the land usage around the airport could be changed in the long run over the next 10, 20 years?

Mr. **Rosmarin**. Yes. We certainly do not plan to embark upon a program that is under way in Los Angeles, if that is what you are driving at, where these is massive land takings.

I think we look upon this in terms of future planning. We have very viable and dynamic communities surrounding Logan so that when you talk about land use planning in and around an airport as active as Logan you have got to consider the fact that these are fairly densely populated areas where communities have evolved over many, many years, several generations, and where people are not easily relocated. There are many situations in families—you have two, three generations having been born, grown up, have their ties and their roots in this community.

So that in terms of trying to provide for a viable program of land use planning and zoning in this area frankly speaking, I think we have got to come to grips with the existing situation rather than embark upon a massive plan.

In terms of future airport locations, however, I think you are very, very much on point here. And I think now that we have a government structure that can take a broad overview rather than from a viewpoint of each agency, we expect now to have this kind of planning for future airport locations, particularly at the regional level.

This still doesn't make it palatable to many communities, nevertheless, even if you plan a regional airport, but I think you are going to see these problems eliminated.

With respect to Logan, however, there is a question of noise. There is no plan that I have heard of or seen for a Los Angeles type solution. Our thrust—the thrust of our activities and the Governor's legislation, both locally and nationally, therefore, is to move as rapidly as possible to encourage the aviation industry and the airport proprietors to face up to the realities of what is a very impressive problem.

Mr. VON GIERKE. But there are no plans or considerations, for example, to move all overseas operations and long-range operations out of Logan?

Mr. ROSMARIN. No.

Dr. VON GIERKE. Now, with respect to the retrofit program which apparently your State supported, do you have any indication how much this could alleviate the overall noise exposure in the next 5 or 10 years? I think, in general, with the rapid development in new technology and new engines coming in with new aircraft, it is debated very much how much it really would bring by the time the retrofit aircraft would be in the fleet.

Mr. ROSMARIN. I agree with that. I think, however, you have to understand the point of view of a State confronted with this situation. When you are told at the State level—and our Governor has talked with Mr. Shaffer of the FAA, and he has talked with Mr. Brown at the CAB, and many other officials, aviation, industry officials, proprietors—and this is the problem that you get into.

We are told, to begin with, that the retrofit program is prohibitively expensive, that it will take 2 or 3 years to even begin to manufacture the kinds of kits that would produce any change in the situation and, therefore, that in terms of cost, delivery of equipment, and finally retrofitting the entire fleet to have an effect, it would probably be a decade at least before you would have any substantial change.

We then go to the new NASA quiet engine program, and we say: Well, if we are going to put the retrofit on one side, let's talk about the NASA quiet engine program.

And the answer you get back from the NASA people and the other people in the aviation industry is that: Really we have just developed the engine. We haven't even tried it out on a model yet. We don't know whether the engine will work. We don't even have any calculation as to manufacturing this kind of engine. So we put the quiet engine program on the side.

You then talk about noise standards, as we have tried to introduce patterned somewhat after California, and we are told that because of the preemption problem or interference with interstate commerce, that this presents such an intolerable burden that we cannot allow the States to interfere in this area.

So we then say to the officials: Well, if we can't do retrofit, and NASA engine is not good, and you don't like us doing noise standards, what is the answer?

And the answer comes back: Well, the production of the newer and quieter aircraft—particularly the DC-10's and the 747's—ultimately will solve that problem.

But for our region, and particularly the northeast, where 33 percent of our traffic out of Logan goes to New York and 50 percent goes into the Boston to Washington corridor, we feel that the delivery of DC-10's is so far off that we may get 2, 3, 4 a year, but the existing aircraft fleet, the noisy fleet—the 707's, 727's, for example—are going to be with us until the end of their lifetime, which is another decade, so that all that we can see in terms of the future is another decade of the same kind of problem and, therefore, for a Governor to tell his citizens that because of all of these answers we are going to have to wait a decade is an impossible answer to accept.

So that either we are going to have to solve it in some way or the Federal Government is going to have to solve it. But one way or the other someone is going to have to face up to this problem today, and whether—that is why we are pushing hard for the Environmental Protection Agency to be given jurisdiction in this area, because frankly, with all due respect to Mr. Shaffer who is a very competent administrator and very much respected for his views on this, we frankly think that it requires another agency to work on regulating this noise.

Dr. **VON GIERKE**. It really burns down to the question, if you have a certain amount of funds available, or you want to devote a certain percentage of the industry income to noise control, are you better off with retrofitting, or moving forward the date by which you accept only noise-certified engines—aircraft in your fleet.

Mr. **ROSMARIN**. The latter is far more acceptable to us if we could see some inclination—

Dr. **VON GIERKE**. The latter is probably more acceptable and might be more promising although it would show very little activity at the present time.

Mr. **ROSMARIN**. Well, we get, then, to the question of establishing certain noise standards. Therefore, to measure the flow of air traffic and, I think, perhaps that is an interim solution that we would like to see advanced.

Dr. **VON GIERKE**. Well, we have the noise certification standard.—

Mr. **ROSMARIN**. For new aircraft.

Dr. **VON GIERKE**.—for new aircraft. So it is only a question at which stage all aircraft would have to be certified and fulfill this certification, and any year you move this forward, I think you have a definite—

Mr. **ROSMARIN**: Well, the law is quite ambiguous on certification of old aircraft, because it says "economically feasible and technologically viable," and under that broad umbrella I think you could say that it may not be, from the airline's viewpoint either economically feasible or technologically viable to certify old aircraft before the end of their lifetime.

Dr. **MEYER**. Before proceeding to my other colleagues on the panel, the thought has occurred to me that there are some other alternatives, too, that need to be examined.

We have heard testimony with which I am sure you are familiar, that there are also some operational procedures with existing aircraft which are being expressed. One airline has instituted such procedures with some remarkable reduction in noise levels associated therewith, and apparently without compromises in safety. Of course, we in the Environmental Protection Agency certainly would defer to the Federal Aviation Administration on the question of aircraft safety.

There are also some experiments which have been reported in the press to have been conducted by NASA with another airline. Demonstrated at the NASA facility in California, these likewise showed some remarkable reductions in ground noise level from noise just by changing the operational procedures. So that somewhere in between all of this frustration, which you have expressed rather succinctly, there may be some intermediate measures that we can do also and which ought to be examined.

Some of those rules and regulations obviously would be subject to FAA approval. The question then arises if Logan Airport is operated by an instrumentality which is a creature of the State legislature, then perhaps in conjunction with us and the FAA some of these sort of things can be instituted under the proprietorship and control requirements. And we would look into this with you.

Mr. **Rosmarin**. We would be more than welcome to cooperate with you in this area.

Dr. **Fidell**. I have first limited comments and then perhaps a broader one.

First, you have continuing references to the wonderful experiments done in California and progress made in California. As a Californian, I would like to tell you that California is not yet a haven of quiet, and that I thought we were just being quiet. And so one should not take too much succor from hearing about the wonderful things that happened in California.

Secondly, I would urge the EPA to use the Governor's statement as a useful expression of his political concern for noise control issues, but also that its nature is as revealing by what remains unsaid as what it says.

I take exception, for example, to the Governor's contention that noise, by its essential nature, is a localized problem. I think this is true only in a very restrictive sense, and when the Governor says "localized" perhaps one might read between the lines and say locations where it insults people most are related to the excessive economic status of the people who live there, and in recent years, certain people have learned that they have the right to complain and be heard, that the Governor's concern has been sharpened.

I think also that one should not expect from the Governor's testimony technical acumen of the sort which perhaps had been expected and that, nonetheless, despite all my comments, I do find it a useful expression of his political concern.

Dr. **Meyer**. One of the things that I think is most important in this statement is that it very nicely stated the problem we have heard elsewhere. Retrofit of aircraft is a difficult problem; it is a long way off. A quiet engine—what it really should be called is "a quieter engine program"—hasn't yet been tried. There are all sorts of legal questions as to what can be done, and so what do we do? You have laid the challenge out that something has to be done. How we are going to get at it is one of the purposes of these hearings.

A question was raised by one of the participants about nervous disorders as one of the prices paid by airport neighbors. Since virtually the entire portion tomorrow is going to be devoted to physiological and psychological testimony by a wide variety of experts, I think I will wait until then. I think that answer as to the differences of opinion on that subject will be brought out at that time.

Thank you very much for bringing the Governor's message to us.

Mr. **Rosmarin**. Thank you.

Dr. **Meyer**. At this point, I would like to take a 5-minute so-called "ecology recess" before continuing with our morning witnesses, to be followed by Mr. Callaghan of the Massachusetts Port Authority. And so we will take a 5-minute stand up ecology recess.

(Short recess.)

Dr. **Meyer**. If we can reconvene after this brief recess, I have several members of the State legislature here. The legislature, as most of the local folks know, is in session, and therefore, these men have to be available for quorum calls and things of a similar nature. So I am going to first ask the Honorable Ralph E. Sirianni, State representative, if he would come forward; and then I will ask the other member of the State legislature. We, from the executive branch of the Federal Government are always happy to hear from members of the legislative branch, be they at the Federal or the State level. So, glad to have you here, sir.

## STATEMENT OF THE HONORABLE RALPH E. SIRIANNI, JR., MASSACHUSETTS STATE REPRESENTATIVE, BOSTON, MASS.

Mr. **Sirianni**. Thank you very much, Mr. Chairman, members of your distinguished panel:

My name is Ralph E. Sirianni, Jr., and I represent the Eighteenth Suffolk, the town of Winthrop. Winthrop has been named here several times this morning. And I thank you for taking me out of turn. We are trying to prorogue up at the State House and this is a very trying time.

Mr. Chairman, I would like to add to my long list of accomplishments, hopefully, in my 7 years as a member of the Massachusetts legislature, having appeared before the DOT, HUD, the HEW, the FAA, and now the EPA. In my 7 years, I have been fighting the Massachusetts Port Authority and Logan International Airport in regard to its expansion programs, and so forth.

Mr. Chairman, I am delighted that today a new agency, you might say, has now entered into the area of trying to curtail to some degree the very serious problem of noise, as it pertains to the Logan International Airport.

I might say that, first, I would think that this Federal agency could do something meaningful in regard to construction noise, jack hammers, trucks, automobiles, chain saws, and things of that nature, and I am sure that on this level there has to be some Federal regulations and standards, and only there can this be accomplished. I don't think it can be done on a local or on a State level.

On the other hand, I think that airport noise is a different animal. It is unique. It is unique in this sense: that the people who are affected by airport noise are those people who are living in the close proximity, within a 10- to 12-mile perimeter of an airport, a major airport. So that actually not all of the people of this country feel the wrath of the jumbojet or the jet aircraft as we know it. So it is unique in that sense, and I think it has to be approached from that particular avenue.

I might say, again, being in political life, it is very easy to be critical of either Federal, State, or local agencies, but hopefully when I am critical, I offer what I would consider a good alternative. Critical of the FAA—the FAA, and I have charged this before, within the past 5 to 7 years, that they are industry-oriented. In fact, I might go as far to say that they might even be industry-controlled at times. At least I have felt that many times in many of the decisions that they have made.

We have talked about operational procedure in regard to airports, how it can be curtailed, how it can be handled. Today, gentlemen, I hope to offer—and it is not unique; I did this 5 years ago—I suggested that our particular problem can be corrected on a long-range program by removing the noise from the people rather than the people from the noise. And I say that because I feel very strongly we have a good, honest, sincere alternative in that we can utilize the harbor islands as an airport for the huge aircraft.

Now, I will qualify this and I may jump around because, I am sorry, I don't have a prepared statement because I was only notified yesterday that this particular committee was sitting.

I suggested 5 years ago that we utilize the harbor islands as an alternative to the expansion of Logan Airport, and I hopefully am not going to be misunderstood at this point because I don't think —and I'm being a very realistic and a very practical man—that you can displace an entire airport that is worth better than $300 million—probably more like $500 million.

On the other hand, Logan International Airport, or the Massachusetts Port Authority—and rightfully so—should be expanding for the economic growth of not only Massachusetts but of all of New England. But they can do so in a very sensible and practical manner. They can utilize the harbor islands for the major runways—the large runways. Now, I know that this is scientifically, technically, and economically feasible.

A few years ago, a group of student graduates from M.I.T. did somewhat of a study in regard to this, and I know that also in the Scandinavian countries, like Denmark and Sweden, they are now building an offshore or harbor island airport far removed from the people.

I think this is the only practical solution, gentlemen, that we can approach this very serious problem. I just think that going along trying to set operational procedures, suggesting that noise standards and levels can be met—they absolutely are not going to be met—not within our lifetime.

I think that the people—at least the people that I represent in Winthrop—have reached the end of their endurance when it comes to the noise problems.

It has been said here this morning by Mr. Salvucci, representing the Mayor, and also by Mr. Standley, and by Mr. Rosmarin from the Governor's office, and I am sure you will hear more technical testimony in regard to the effect that it has on our educational system, the schools, the hospitals, and I am sure that you have had this and you have heard this throughout the length and breadth of this country in every major airport area, so that it is nothing new to you.

Hopefully, today I can interject that again the only really practical approach to this problem is to remove the airport noise from the people, and I am a little disappointed that our former Governor, who is now the Secretary of Transportation, Mr. Volpe, did not at the time he was the Governor—I made this proposal 5 years ago; it was studied but it was not studied to any great extent. Hopefully through the Environmental Protection Agency you can come back to Congress or to the proper agency and reflect this as a thought, maybe from a voice in the wilderness, I might say, because it seems as though I am the only one—at least in Massachusetts—that is suggesting this sort of—well, let's say—a very drastic, but I think a very exciting suggestion that is, again, very economically feasible, technically and scientifically feasible. I think it can be done.

Only recently I spoke to—and I have an awful lot of airline people that live in my community because of its close proximity to the airport—airline pilots who, completely off the record, have said to me that I am 20 years ahead of my time, that some day this will be a reality, that is the only solution to the problem.

And, gentlemen, I am not going to take too much more of your time. I thank you for the opportunity to have testified before this, again, my many accomplishments of the long list of Federal agencies—and at times very frustrating, I might say, that in the 7 years that I have been involved with this problem really I haven't seen anything come from any of these hearings. And I don't mean that to be critical to this distinguished body. But when you go back to Congress, you have people that you have to answer to. So, being a member of a legislative group, I know the problems that you face. But, again, thank you very much.

Dr. **MEYER**. Well, thank you, Mr. Sirianni.

Would you be willing to answer a question or two from the panel?

Mr. **SIRIANNI**. Yes, sir.

Dr. **MEYER**. As I said, one of the purposes of these hearings is to get all possible alternatives into view.

Mr. **SIRIANNI**. Sure.

Dr. **MEYER**. So, before I ask a question or two, I will ask the panel, starting on the right, Dr. Botsford.

Dr. **BOTSFORD**. I have no questions.

Dr. **FIDELL**. Just one or two clarifications. First of all, I have heard it said many times that the FAA is in bed with industry. Well, their charter says that they are supposed to be at least one foot in the bed. I mean they are supposed to.

Mr. **SIRIANNI**. Not both feet.

Dr. **FIDELL**. Perhaps. And as for your comment about the capture of Federal regulatory agencies by the varying industries they are supposed to regulate, that has been said, too, and I don't know what can be added except perhaps to urge the Environmental Protection Agency to study ways of avoiding that same fate.

Mr. **Sirianni.** Fine.

Mr. **von Gierke.** Your suggestion about the harbor islands sounds very intriguing, and I guess not every city in the country has harbor islands available for it. So, I guess, in a broader sense, this illusion is, as I tried to express before, total planning of the transportation facility and the airport, including the land use around the airport.

Now, I don't necessarily mean that this land use has to be around an existing airport, but I think you could plan an airport facility for the future and start from scratch. But the one specific question I have is: Has this report by this M.I.T. group been published, and is it available?

Mr. **Sirianni.** Yes, it is, and I am sure—I think it's Dr. Shurcliff—I am not sure—but I am sure this is available from M.I.T.

Dr. **Meyer.** Thank you.

Milt.

Dr. **Whitcomb.** I really have no questions. I just wanted to comment positively on a very candid and lucid statement.

Mr. **Sirianni.** Thank you very much.

Dr. **Eldredge.** Nothing.

Dr. **Meyer.** I have a couple of questions which some people have sent to me. One of them clearly ties in with the thought that I had jotted down. Of course, any new proposal like this has to take into account the ecological implications of its possible impact.

This point was brought out when we were having the hearing in Chicago. There was considerable discussion about a downstate airport to relieve part of the traffic which apparently had been scheduled for an area which was considered important from a recreational viewpoint. So, of course, I believe you agree one ought to look at the technical and economic and ecological considerations and weigh them all.

Mr. **Sirianni.** There is no question about that.

Dr. **Meyer.** Right.

Someone has asked a question which I would put to you: Is there a possibility that an airport on a small, man-made island would create fogs coming in and out without warning?

I don't know whether you have any information on this thing. It is a technical question.

Mr. **Sirianni.** Yes, it is a very technical question and I might answer it just in this way: Winthrop is an island surrounded almost completely by water. You can get to it by bridge in one section and by cause way from another, and I think Logan International Airport is somewhat of an island, although it would be moved about 6 to 8 miles out into the Boston harbor. I don't think that this is going to be a major problem.

If we have fog anywhere in the harbor, Logan Airport gets it and so does Winthrop now, so I don't see this as any major problem.

Dr. **Meyer.** I think the main point here is, of course, as you have already agreed, that one has to do a complete study and that ties in with my colleague Dr. von Gierke's view that you can't look at this in isolation, you have to look at the total regional planning activity.

Since this testimony will wind up in the appropriate committees of Congress, your views certainly will again be reflected, sir, and I intend to look into them further also.

Mr. **Sirianni.** Fine.

Dr. **Meyer.** Thank you very much.

Mr. **Sirianni.** Thank you very much, sir.

Dr. **Meyer.** I appreciate your taking the time to be with us.

At this point, I would like to ask another member of the legislature, the Honorable Monsignor Mimie Pitaro, State Senator from East Boston, to speak to us. Pleased to have you with us, Senator.

## STATEMENT OF THE HONORABLE MONSIGNOR MIMIE PITARO, STATE REPRESENTATIVE, FIRST SUFFOLK DISTRICT, EAST BOSTON, MASS.

Msgr. **Pitaro.** Thank you, Mr. Chairman.

Let me say now, sir, I am just a Representative. I have been elevated, I believe, but I am a State Representative, not a Senator.

Dr. **Meyer.** The record will be corrected.

Msgr. **Pitaro.** The copies of my address are being Xeroxed at the present time.

Unfortunately the Xerox machine was late in arriving, so we hope before the afternoon you will have copies of it.

Dr. **Meyer.** Very good, sir.

Msgr. **Pitaro.** In fact, our discussion today perhaps is the reason why I am a State Representative because of the involvement in the past few years with the airport problem.

As an elected Representative and a resident of East Boston, I find it difficult to outline for you the full range of problems with which I have had such a long time and opportunity to become acquainted. Basically, however, I believe that airport noise has been and will continue to be the greatest single threat to the habitability of East Boston. Further I feel that the historical character and behavior of the airport proprietors, the aviation industry, and the FAA has constituted nothing less than criminal neglect of the health and safety of the people of our community.

These observations are not new, but often pro-aviation forces charge that belief in them is confined to small groups of die-hard airport foes and environmentalists. However, my feelings about airport noise are shared by the overwhelming majority of 40,000 East Bostonians, as evidenced by a recent Boston Globe poll which showed that 83 percent of a random sampling of East Boston residents counted airport noise as their most serious problem. Impartial observers have also indicated the severity of our noise problem. Governor Sargent's task force on inter-city transportation concluded in April of this year that the airlines and the MPA, proprietors of Logan, had neglected to consider seriously the need for alleviating the serious noise problem around Logan, and that meaningful noise abatement for airport neighbors was the first priority for airport policy.

Recent studies by Bolt, Beranek and Newman have over and over again documented the impact of airport noise on East Boston. These studies indicate that virtually all East Boston residents live within the NEF 30 contour, the area within which soundproofing of schools and churches become necessary and soundproofing of homes desirable. Moreover, the densely populated neighborhoods around Neptune Road and Bayswater Street in East Boston are well within the NEF 40 contour, the area which is deemed generally unsuitable for residential land use. These studies further maintain that noise exposure around Logan will increase as the airport becomes busier.

These polls and studies reveal the magnitude of the problem but cannot reveal the urgency of finding a real solution for it. This sense of urgency comes from an appreciation of the sufferings of the people of East Boston. Homeowners, who years ago bought houses in a quiet residential neighborhood, now find themselves forced to desert a community which they dearly love. Tenants, many of whom are lifelong community residents, must choose between daily annoyance and discomfort and a search for new quarters which could lead to economic hardships.

Some of our citizens wear ear muffs to bed as a last ditch attempt to secure a night's rest without interruption at night. Children are robbed of the sleep which is so essential to their health, and in the daytime they must cease playing and cover their ears at the approach of low-flying jets. Adults become irritated. Some children are traumatized. Schooling of our children is jeopardized by frequent jet flights during the school day.

Last June the tolerance of Neptune Road residents reached the breaking point. During a weekend of heavy use of runway 15-33, constant noise and vibration from planes flying as low as less than 60 feet over their homes forced the people to threaten a march on the runway in order to prevent further flights. Many of the people feared for their lives because of the proximity of the aircraft to their rooftops. June's situation was extreme because of the high frequency of flights, but low-level flights and ear-shattering noise are daily occurrences on Neptune Road. Since severe conditions continue, a crisis can develop at any time, but it would be tragic indeed to postpone alleviation of suffering until the outbreak of a crisis.

Though jet over-flights constitute by far the most serious airport noise problem, there are other severe annoyances. For example, Maverick Street in East Boston abuts an aircraft maintenance area at Logan, and residents of that street and the rest of the Jeffries Point neighborhood are often subjected to deafening engine testing and warmups. Trucks constitute another serious noise problem. Residents of Neptune Road who abut Logan airport air freight terminals often complained about early morning trucking operations which both in timing and severity of noise seem to deliberately harass the neighborhood.

Finally, many East Boston residents, especially those whose homes abut the Callahan Tunnel and those along the main streets in the Jeffries Point area must endure the passage of a long stream of heavily laden and extremely noisy gravel trucks which, from 4:30 in the morning until after dark, carry fill for the expansion of Logan onto the Bird Island mud flats. Since May, I have had constant communication in reference to this to public safety officials with very little cooperation from the Mass. Port.

Our airport noise problems are thus numerous and severe. So fair, we feel that government has been unresponsive, especially in the area of noise from jet airline operations. Local government, though slow to respond, can be partly excused. First, they do not have sufficient financial resources to invest in abatement programs. Second, Federal agencies, especially FAA, have claimed preemption in the field of airport and aircraft regulation. Third, financially powerful interests have fought local attempts at regulation.

The Federal Government must act, however, if crisis is to be averted. The first priority is abatement of noise at the source. The Federal Government, through legal coercion and/or financial incentives should encourage airlines to retrofit and/or replace old noisy aircraft. If the FAA, out of consideration for the financial prosperity of airlines, refuses to adopt strict rules on aircraft noise emission, we hope that the Environmental Protection Agency will not hesitate to do its duty.

The second priority, though of almost equal importance, is the regulation of airport operations to minimize noise impact on surrounding neighborhoods. An essential step in this effort is the establishment of a national nighttime curfew on jet flights. A locally imposed curfew could not stand up against constitutional objections and complaints of industries which ship freight by night. Yet a curfew is necessary if the psychological and physical well-being of airport neighbors is to be protected. Besides the curfew, Federal regulations should set up permissible levels of noise exposure which must not be exceeded by airport operators. These regulations should include limits on individual missions and on composite noise exposure, and clearly define the extent to which localities can set their own standards. New Federal rules must also provide mechanisms for strict monitoring and enforcement of compliance with noise abatement regulations.

Finally, the Federal Government must take the initiative in making reparations to those who have suffered and who will continue to suffer from airport noise even if strict noise abatement were practiced. Federal money which played so important a role in the construction of jetports should be available to pay for the environmental costs of those jetports.

Projects which must be financed include soundproofing of schools and homes, construction of replacement housing for persons displaced by airport expansion or forced to vacate by excessive noise. These reparations are necessary to balance the economic benefits of expanding the aviation industry with the costs of that expansion to the human environment.

It is high time that the Federal Government should take an active and effective role in protecting its citizens from the dire effects of uncontrolled airport expansion. East Boston has suffered too long and has paid too heavy a price.

Dr. **Meyer.** Thank you, Monsignor Pitaro.

Would you be willing to accept any questions?

Msgr. **Pitaro.** Surely.

Dr. **Meyer.** Dr. Eldredge, do you have a question or comment?

Dr. **Eldredge.** Yes. It occurs to me that you might be able to supply another kind of information that could be helpful to us. During the time that these airplanes are flying over, the noise masks your ability to hear things like speech or other sounds, and there is the obvious problem which has been discussed before that has to do with the problems in schools and churches where this interrupts communication, but my question is directed toward another aspect of communication. This is the kind of communication that takes place in emergencies.

Do you happen to know, from your experience in your district, of any instances in which someone was injured or there was an accident because communication of a warning shout or some instructions was not able to get through, and in this way create an important situation?

Msgr. **Pitaro.** Well, doctor, we live in constant fear. I think there is a pall that hangs over the entire community. There is always the fear that there might be an accident.

For instance, we have a storage of some 30 million gallons of fuel within the area—a few miles of the airport—and I think it is a moral issue, that if there should be—and there always can be—an accident, then there will be a conflagration that would be a matter of history and an entire city would be wiped out.

However, on occasion—many occasions—antennas have been knocked down; plaster has fallen from the ceiling. I had a friend who had some lovely crystal all shattered one night because of the jet noise and the only answer to that was: "Let us know what time it occurred, by what airline, and what flight number." And the whole thing is under, you know, that type of negotiation.

I have had people complain to me that their curtains just fell down from the windows. Now, that is a little too close, I would say.

Do we need an accident to—

Dr. **Eldredge.** No. I don't mean that kind of accident. I mean something that happens to people because people can't communicate. In other words, someone says, "Look out, this is going to fall on you." This has nothing to do with the airplane; it has only to do with the fact that the person is temporarily deaf because the airplane noise prevents him from hearing a conversation or an instruction of some kind.

Msgr. **Pitaro.** Well, I do know people cannot watch television at night in their homes because of the noise of the craft.

And, you know, it is a strange thing. There is a lot of shouting going on. I have a school—I have a grammar school and a high school, and our youngsters are excessively noisy. They never talk in a whisper or modulated; they are always yelling; they are always shouting. You have to tell them to keep quiet, you know.

I wish there could be a study made of the impact on the hearing of these youngsters on a yearly basis, say, going back—if we could get the records of the testing of the hearing of these people and compare it now, 10 years later, or even 5 years later, to see have there been any effects.

I had a woman who came to me just a short while ago, and the doctor told her that her hearing loss was due to the jet traffic noise.

So the normal living to which we feel we are entitled is disrupted by the airport.

Thank you.

Dr. **MEYER**. Dr. von Gierke.

Dr. **VON GIERKE**. I wonder if you have any comment about the proposal we just heard before by Representative Sirianni about the airport on the harbor island.

Msgr. **PITARO**. You are putting me on the spot now, as two legislators. (Laughter)

Dr. **MEYER**. You don't have to answer, of course.

Msgr. **PITARO**. No. We speak about environmental impact, and in the process of my confrontation with the airport, I don't feel we can solve our problem by putting the problem upon somebody else.

If we are suffering from the impact, environmentally, from our airport, then I think we should take a second look upon what that impact is going to be upon the surrounding communities. We do not have people here from South Boston and Dorchester, who I think might be badly affected by a harbor airport.

Then, the time element—you know, we don't build things over night. We take a long time. If it were approved it will take an awful long time. In the meantime, we are being subjected to that same noise level.

I would recommend that perhaps the airlines would cooperate with community people and try to control their flights, consolidate many of the flights. I understand that last year that the average people per flight out of Logan was 39. You have all these aircraft taking off at the same time with an empty carrier. Well, that is really, I think, unnecessary. Let's coordinate some of our flights, then make an effort at least to be conscious of the people. I think basically here—and I don't like to become argumentative and take too long to even begin to narrate to you the confrontation we have with Massachusetts Authority—but one of the great problems is their insensitivity to the problems, their lack of cooperation, the lack of sincerity in trying to sit down and solve the problems. Instead of the Mass. Port Authority sitting down and trying to explore to come up with a noise program, they have used the lobbyists very effectively to defeat these bills, and these bills have been worked over and worked on with a great deal of time and effort. But the highly paid lobbyist who does his job very well was able to defeat the legislation.

This is an area in which they could have sat down with the community members and said: Okay, we recognize there is a noise problem. Now let's do something about it.

They have a noise office, if you will. You call up and complain to them, and the people are insulted. "We will put your complaint on record." And recently after the Mass. Port withdrew its application for the extension of a parallel—for the putting in of a parrallel runway after a series of hearings and an environmental study that proved to be unacceptable, the Army Corps of Engineers just dropped the whole business, and the people were getting the response: If you hadn't stopped our new runway, you wouldn't have had this noise. What do you expect from us anyhow? This type of attitude is strange.

I feel it is very important that we should be able to sit down and negotiate some of the problems, but it is difficult to negotiate with an agency whose attitude is so arrogant and so insensitive, and this is a great problem. This is a great problem.

I know that following me will be a member of the Mass. Port Authority and I am sure he will tell you what good friends they are to us, but let me assure they are not good neighbors at all.

And then I would like to also point out what has been pointed out before: that we were there first. Many, many other airports came in an area and they built around it. Well, fine. If you knew it was there, then it is your fault, but we were there first.

I recall in 1946 I flew out of Logan, at the time, on a DC-3 and I thought that was a tremendous adventure—my first flight to Los Angeles—I think it took 24 hours—my family lives in California—24 hours, after nine stops, you know, and we thought that was great. Little did I realize that some 11, 10 years—no, 25 years later, I would be fighting this wonderful thing called the airport and air travel.

Mr. VON GIERKE. One more question—

Msgr. PITARO. I am sorry, I didn't mean to be carried away.

Mr. VON GIERKE.—about the problem of night curfews, which is certainly one of the immediate steps one can or could take to alleviate the problem without any technological breakthrough or anything.

Now, I have heard the argument many times that this is and should be the responsibility of the airport operator, and that the Federal Government is not really too welcome to step into this, and I think at the present time the Logan airport operator can take this position and have a night curfew.

Msgr. PITARO. We have submitted legislation, doctor, for a night curfew, and the answer we receive all of the time is that it violates interstate commerce, that the FAA has preempted our rights or the rights of the—well, the rights of the State, because our airport—the proprietor of the airport is the State itself—that it has preempted our rights to establish curfews.

We filed a bill to ban the SSTs from Massachusetts, and it was ruled unconstitutional because it interferes with interstate commerce. These are the answers given to us by the Authority and it has been a real hard struggle trying to get some of our legislation through. In fact, we have gotten none of it through—that is how hard it has been.

The community, for the past 3 years, have filed numbers of pieces of legislation for the purpose of trying to curb the airport and get nowhere. Always the FAA regulations forbid it, and I feel that it does not preempt all of the obligations and the responsibilities of the local proprietor.

Dr. FIDELL. Since you mentioned reparations, Mr. Pitaro, let me propose—offer a modest proposal, in Mr. Swift's sense. Would your constituents accept a $1,000 a year subsidy to tolerate the aircraft noise and relieve you of the political pressure?

Msgr. PITARO. No.

Dr. FIDELL. Would they accept $10,000 a year? What I am trying to establish is: Is there a price which you would pay in your community—

Msgr. PITARO. To live there?

Dr. FIDELL. Yes.

Msgr. PITARO. The price we are paying is the fact that we love East Boston. In a confrontation with the Director of the airport 4 years ago—before our confrontation in my rectory—the director of the airport very blandly said, "Well, you are slum dwellers and we will do you a favor to move you out."* And then they operate on that premise.

But actually we love East Boston. I am there only 7 and a half years, and I feel a part of it. I am not a native of East Boston. I have spent most of my priesthood in the city around East Boston and we like East Boston and we are staying there even at great sacrifice, and these people up at Neptune Road are holding out. They want to stay there. It is a very lovely area and they want to stay there. Bayswater is one of our lovliest areas of East Boston. These people want to stay there. They don't want to move. They just want some sort of regulation.

We know that a nighttime curfew would really be a great help. If you can get your night's sleep, then, you know, the day isn't so bad because there is so much noise anyhow you are not conscious of the noise.

But, for example, we have these gravel trucks. I have heard people say, "We can't sleep at night because of those damn planes. Now we can't sleep in the morning because of the damn trucks. They have got us coming and going."

So, 4:30 in the morning, they have to get up. Not having air conditioned homes, they have to close their windows to the height of the summer, and during the summer heat they suffer. Well, a lot of this is not necessary.

I don't think it's a question of if you give me $1,000 I will suffer gladly; $10,000 I will suffer gladly. I think the people want some sort of an honest effort made on the part of the airport to do something about abatement of noise, and I offered as a suggestion perhaps some sort of control over their flight patterns.

Dr. FIDELL. Well, what was the thrust, then, of your suggestion that reparations are necessary to balance economic benefits, and so forth?

Msgr. PITARO. Well, I think that perhaps—I don't know—that, as a matter of fact, presently as a result of the Governor's message, as the Governor said in July, presently there has been a committee formed with the Mass. Port Authority board of directors to discuss the possibility of moving some of the people of Neptune Road to another area, and I talk about this as a matter of reparation.

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*Refutation of this statement submitted by Massachusetts Port Authority appears at the end of Msgr. Pitaro's testimony.

Dr. **Botsford**. I would just like to comment—the two sources you have complained about—aviation and trucking—are businesses. Their purpose is to make profits by providing a useful service.

Now, we have seen here—Mr. Standley testified earlier that they are imposing noise restrictions upon other Boston businesses by placing limitations on noise at their lot lines and I dare say they also have curfews on some other business activities like construction. It is very common to have that.

So I agree with your feeling that there is an unresponsiveness in this area when you have a similar situation in other businesses that are treated quite differently.

Msgr. **Pitaro**. Yes, I agree with you, doctor. They seem to be kind of immuned to and above all kind of criticism and control. I know that there was a bill this year to make them subject to some of the zoning controls, some of the code controls about building and zoning, and as of yet that is still buried in committee. It just so happens that it has been buried in committee.

So they seem to always be above what others have to comply with. Even in the matter of the trucks, they will break the speed limit. They are overloading 28,000 pounds per load. As a matter of fact, there has been an investigation recently held at the State House on the trucks and their overloading. The Registrar put out his entire force and admitted to me in writing that they were breaking the law, speeding and overloading, but he didn't have enough men to be able to govern it.

You see, I come right back to the point that it is not necessary for these trucks to break the law, and I think the Mass. Port Authority could demand that it follow the law. But when these people pay so much per load, there is a long line waiting at 5:00 o'clock to unload so they will be first in line when they go back to the tunnel and without any consideration of safety for the region people.

I got back to my premise: the insensitivity of the Mass. Port of acting in areas in which no legislation is even necessary, but a voluntary cooperation on their part.

Did I answer your question, doctor?

Dr. **Botsford**. It was more of a comment than a question.

Dr. **Meyer**. One of the things which you have brought out has been reported to us in other hearings, particularly at Atlanta, Dallas, and San Francisco. That is the intensity of community reactions to the encroachment upon other areas of the airport operation. This may be scant comfort to you to know that the same problem has been reported with equal vehemence in other locales. It is one that does require a great deal of consideration because of the fact that people are inhabiting areas that they have lived in for a long period of time. They were there first, in many instances, and it is one that does require some very special consideration.

I will be anxious to hear from the other side of the story, as you indicate, from the Port Authority, as to their views as to what they have done. But I would like to ask this question, and I also intend to direct it to Mr. Callaghan. Is there any organized community airline airport operator organization such as exists in some communities? Do they have a—

Msgr. **PITARO.** A noise abatement—

Dr. **MEYER.** Yes, council of some sort.

Msgr. **PITARO.** They do have a noise abatement committee which meets once a month. Until recently I was not informed that there were meetings on with regard to it. In fact, one of the hearings at the State House—I happen to be a member of the Transportation Committee at the State House—and it was made known that this committee existed. But there was very little community participation on the committee.

Dr. **MEYER.** I see.

Msgr. **PITARO.** Unfortunately the meetings that they have had conflicted with prior meetings at the State House and I wasn't able to attend although I sent my secretary to represent me at these meetings.

Dr. **MEYER.** The curfew problem is a subject that we have rather extensively explored as part of our report to the Congress and there seems to be a diversity of legal opinion on this subject. I think the record ought to show this.

For example, the city of Santo Monica, California, was quite successful, since it owned the airport, in establishing a curfew which simply said no jet aircraft may take off between 11:00 p.m. of one day and 7:00 a.m. the next day. This was upheld by the State Supreme Court and was not carried further on the basis that there wasn't any specific legislation on the Sate or Federal level.

There was a valid exercise of that municipality's police powers. However, there have been some other rulings particularly in light of the more recent enactment of the Federal Aviation Act of 1969 and the 1970 Act relating to the authority of the Federal Aviation Administration.

But certainly the California law with which you are familiar has been based on the presumption that the proprietors of an airport can establish certain rules. Therefore, it is an open question and hopefully our report to Congress, which will be available to the State legislatures as well as the Congress, will provide some guidelines in this area which obviously needs really close examination.

With regard to the indemnification, I think we ought to comment that the indemnification is a measure of recompense for an injury but still doesn't take the injury away, and we ought to become more concerned with cause of the injury.

Thank you very much, sir. It has been a very stimulating and informative discussion. It is one that I would like to call to the attention of the members of the panel. I hope we will think of it when tomorrow we talk to some of our colleagues in acoustics and noise-related sciences. It is very interesting the intensity of people's reaction that are really involved in this problem.

Msgr. **PITARO.** May I make one last comment?

Dr. **MEYER.** Yes, sir.

Msgr. **PITARO.** We have in our area a very active Mental Health Clinic—a very active Mental Health Clinic. And I wonder whether any study can be or would be made as to the effect of noise upon the mental health of people. I personally feel that the business of our health clinic is the result of the airport problem. I just offer that as a thought.

Dr. MEYER. This is an area we should certainly examine.

Msgr. PITARO. Thank you, Dr. Meyer.

Dr. MEYER. Thank you for coming, sir.

(The Massachusetts Port Authority's response to Msgr. Pitaro's statement follows.)

December 28, 1971

massport
470 Atlantic Avenue, Boston, Massachusetts 02210 (617) 482-2930
JOHN LARKIN THOMPSON,
  Chairman
NICHOLAS P. MORRISSEY,
  Vice Chairman
THOMAS G. BROWN, JR.
ANTHONY P. DeFALCO
FRANK L. HARRINGTON, JR.
EDWARD C. MAHER
REV. ALBERT J. SALLESE
EDWARD J. KING,
  Exective Director

Sir:

Mr. Callaghan has already advised you of my shock by a portion of Monsignor Mimie Pitaro's testimony before your EPA Noise Abatement Hearing in Boston, Massachusetts on October 27, 1971. The statement that the Director of the Airport said blandly or otherwise "Well, you are slum dwellers and we will do you a favor to move you out", is totally untrue. While I presume that this remark refers to me (similar remarks referring to me having been made on prior occasions) I did, in order to be sure that no one in any such capacity in our organization made such a remark checked with our Director of Aviation who indicated that he never said such a thing and who I assure you would not.

We recognize that we do operate an airport, that airport noise and pollution are problems. We recognize your function in trying to come up with meaningful relief at the earliest possible date. We always have and always will continue to cooperate in every way with any effort to reduce noise and/or other pollution, visible and otherwise. We regret that your visit to Boston in an effort to help occasioned this little extra paper work. We could not, however, permit an absolutely untrue statement of this personal and derogatory nature to be recorded without a response.

MASSACHUSETTS PORT AUTHORITY
Edward J. King
Executive Director

Dr. MEYER. It is now 12:30, and it is getting to the point where the Chairman has to make a decision whether to hear from the next witness or whether to adjourn for lunch.

We have another witness who has indicated a need to get away very early. Because of the desire for continuity of interest, I do think, at this point, rather than terminating the discussions, that I should like to ask Mr. Callaghan of the Massachusetts Port Authority to come forward, while all of the views that have been expressed are fresh in the minds of the members of the panel.

The interesting thing about these public hearings is we have the opportunity to hear both sides of an issue in view of the public, the press and all concerned. We don't attempt to take sides. We are only attempting to elicit information.

## STATEMENT OF THOMAS P. CALLAGHAN, ASSISTANT TO THE EXECUTIVE DIRECTOR, MASSACHUSETTS PORT AUTHORITY, BOSTON, MASS.

Mr. CALLAGHAN. Thank you, Mr. Chairman, and members of the panel.

My name is Thomas P. Callaghan. I am Assistant to the Executive Director at the Massachusetts Port Authority, and I am the coordinator of the Logan Airport Noise Abatement Committee.

I will try to stick as close to the facts as I can and not attempt to rebut some of the things that I consider to be more than slightly exaggerated.

First, I would like to give you gentlemen a copy of the Logan Airport Noise Abatement Committee measurements.

Dr. MEYER. The record will show that these will be included following the testimony in the record.

Mr. CALLAGHAN. I have been the coordinator of the Logan Airport Noise Abatement Committee since 1967. Prior to that time, we had an Air Traffic Cooperation Committee, perhaps to avoid the words "noise abatement" at that particular time, back in 1960, and I also headed up that committee.

So I think I have had considerable experience in regard to what is actually happening at Logan Airport.

Just a word or two on the highlights of this particular committee. We have four community representatives. We make a selection of those representatives, but we have made a practice of offering the representation to the chief complainant in the community; the person who complained the most. And, in some instances, we have obtained that particular individual; and in other instances, we have had to work quite diligently to find someone who was willing to represent the community in a very sensitive situation.

We have imposed on the airlines operational restrictions which we consider to be about as severe as in any major airport in the country. For example, we were the first airport, I believe, and perhaps are the only major airport at the moment that prohibits maintenance runups between midnight and 6:00 o'clock in the morning.

I could give you—and I would be glad to provide it if it has any particular interest—because we certainly would like to have you people cooperate in any operational measures that you feel are worthwhile.

We invited the committee to come here, as a matter of fact, if it happens to be part of your knowledge.

We sent an invitation for the committee to be here to listen to the problems. We don't derogate in any sense the seriousness of the aircraft noise problem in certain neighborhoods of East Boston, Winthrop, and also Revere. Yet, as you undoubtedly realize, we happen to be a no man's land between the airlines and the people, and no one has solved the problem.

We believe that our operational measures, our major responsibilities as a landlord have been exercised. We have had before the committee various people who were critical, and we listened to their proposals, and we gave them every consideration.

Above everything else, of course, safety is of paramount concern to any group which includes airline pilots, and chief pilots, and the FAA. But we do not merely allow the airline pilots or the FAA to dispose of a suggestion merely because they consider it unsafe. We bring it up under different guises at different times with different proponents, and we check on what the other major airports around the world are doing, and we feel that in virtually all instances there are a couple of situations under that form of combative negotiation—we feel that the airlines and the FAA have responded extremely well.

Now, we all know the curfew is a very significant matter in respect to noise abatement. As I say, we have 7 or 8 different measures which are not incorporated in this general program for the south apron and the north apron. We have a subcommittee there which works on the nighttime noises, and we give to that subcommittee—or those two subcommittees—the complaints that we receive.

Now, we received in the past 9 months, 10 months, approximately 1,700 complaints. We received 2,400 in 1970. I don't believe that the figures represent any particular values in terms of whether or not the airport is decreasing the noise or whether the people are satisfied, because there are so many factors involved: the political climate; the type of complaints that are given; the thrust of various situations, including the trucking situation.

So that I am trying to be as factual as I can and I wouldn't claim any particular credit for the drop from 2,400 to probably 2,000 complaints this year. But we do maintain that what we are doing is exercising to the fullest our responsibility as an airport community, and even though we might be termed the landlord, we do have various responsibilities, various influences over our tenants. We don't have much of any influence over the FAA in terms of the flight patterns, but they receive a copy of each complaint. The complaints are discussed at a monthly meeting, and if they involve a certain technicality—if they involve technicalities they are discussed at a subcommittee meeting which is also held approximately once a month. So that the complaint number is Logan 7-3333. It is known to most everyone, I think, that is upset by noise because it was carried on television for many months, carried in the newspapers for probably 2 or 3 years.

I believe that is more or less the outline of the Logan Airport Noise Abatement Committee.

The other point that I would like to make in respect to the past history of the situation is that it was the Port Authority in 1968 that went down to Washington and pressed for the passage of Public Law 94–111. I testified there, and I didn't notice any of the municipal or State officials there at the time.

We met with the congressional delegation and we obtained a unanimous vote in favor of this legislation. And we feel that it is necessary for the Federal Government to exercise the control over the machine itself, because no matter what an airport may do, if you are having diesel locomotives pass over people's heads, no amount of tinkering with that problem is going to do any good. So that we feel very strongly that the FAA should continue to make more stringent its Part 36. We, through the Airport Operators Council, have pressed for retrofit or accelerated introduction of new aircraft, and we leave up to the airlines and the FAA and perhaps yourselves just how that can be accomplished.

We are not here to defend the airlines or the FAA, so I will leave that matter in that particular context.

Now, the problem of facts in respect to Logan Airport, I think, can be summed up by an attempt that was made in 1970 to present the noise footprints around Logan Airport, and I would like to leave for you here—I have only, I believe, three copies—but these copies show, number one, NEF-contours around Logan Airport. The 30 contour to the northwest covers the city of Medford, and just recently HUD put out a study to attempt to really understand what is happening in Medford, and I have copied the pages, and it says that aircraft noise is not significant in the noise levels in Medford.

So that people can talk of 40-NEF curves, and talk of 30, and all of the rest of them, but the fact is that the 40, the 30, are subject to so many different variables that the airport operator is not enthusiastic for them to say the least.

In respect to this northwest situation, the takeoffs at night between midnight and 6:00 o'clock in the morning have been about 90 percent concentrated on the takeoff which begins at the northwest and goes out over the harbor to the southeast. That is an accomplishment which I believe has decreased greatly the nighttime noise.

Also, you must bear in mind, if you will, that it is the cargo aircraft that are taking off at night primarily, and this has a tremendous economic value to an area such as New England which has a product of high value that has to go across the country and around the world. So that we feel that the nighttime noise situation has been reduced to its ultimate insofar as operations are concerned.

If anyone has any other suggestions, we would be delighted to have them. I am not trying to outline all of the things we have done, but the air controllers—and they have cooperated to the nth-degree—they are taking off the aircraft between midnight and 6 o'clock in the morning to the southeast, and they are attempting to land as many as possible from the southwest on a long runway, Runway 4-R, which really doesn't elicit many complaints as far as either takeoffs or landings are concerned. So that that is the general outline of what we have done.

Now, as far as the Port Authority is concerned, you have already heard something of what we are attempting to do in the community.

In the Logan Airport Noise Abatement Committee, one of the representatives is a city planner—I don't want to mention his name because there might be a certain sensitivity in respect to what he is trying to do. He has been on the committee for approximately a year, and recently he revealed two things which I think go to the essence of the problem if people are really speaking of the facts of the situation:

1. We have a hill—Bradstreet Avenue Hill— in Revere, which is affected by approaches to Runway 22 Left from the northeast, and if I say affected, I think you can read something more into

it than that. We had talked casually, not really within the committee, about the value of trying to have some playground area at the top of this hill. He took the initiative and has accumulated a couple of acres of land up there, when it became available, through the Revere City Council, and I think that he has begun a solution to one of the three most sensitive areas that we have.

2. In another situation, he has told us of the variance given by the City Council for a 10-story home for the aged at Revere Beach, which is on the approach line of 22 Left. I have talked with the attorney and with the architect, and we are going to give them the sound levels, and we are going to try to give them whatever we can in terms of soundproofing, and I think that with the attitude they show, they are very much interested in trying to build a structure there which is not going to cause difficulty as far as the people are concerned and as far as the airport is concerned.

So that, along with what Monsignor Pitaro mentioned, an attempt to use the Federal Relocation Act to find a generous means of helping people to leave a noise-impacted area, we feel that we are getting into community involvement just about as deeply as we can. We feel, too, that the city itself has a certain responsibility in regard to the redevelopment of certain areas. And I think, too, that HUD has a responsibility which it hasn't exercised.

Back in 1963, we attempted to work out with the city a buffer zone along Maverick Street in East Boston, and I had a good many discussions with a fellow named John D. Simone, who is the Redevelopment Director in East Boston, and we even had the idea that perhaps the city's share of the Federal program could be exercised by the Airport Authority—that is, its investment in the airport might be considered as the city's share of the redevelopment financing.

At any rate, nothing came of that, although we have talked to HUD any number of times, and in one of the major noise abatement surveys at the airport conducted by the FAA and HUD, we had continual conversations with HUD representatives as to how the airports could develop with Federal, State, and local assistance a program that would be satisfying to those people who for one reason or another felt that they wanted to leave a noise-impacted area.

I say "for one reason or another," because even though we recognize the severity of noise impaction in certain neighborhoods, the fact is that some people stand it much better than you and I especially if they have been conditioned since the first propeller planes landed at Logan Airport. They have a resistance that is just beyond understanding in certain situations.

So that one of the strongest feelings that I have is that the operational measures should be continually improved at Logan Airport but the airline pilots frankly are beginning to feel that pressures are being exerted in respect to operational measures—that is flight measures—that they are not going to cooperate in. We are well aware of Northwest Airlines two segment takeoff, and we are well aware of the 6° landing slope, and then the final 3° landing slope. But, in my opinion, those measures are going to be slow to be accepted as specific measures. I believe that if noise level standards are established and airlines are told to make them as they see fit—to conform to those standards as they see fit—that is an opportunity for fruitful result. But pilots will tell you that one fellow can land at 6° and he might land all of the way down, but they say they are like ballplayers. Some of them are superstars and some of them aren't.

So that I submit to you that all that we want to convey to you and to Congress is that the Massachusetts Port Authority: 1) is exercising its responsibilities as an airport operator; if anyone can improve on them, they are very welcome to come to our next Logan Airport Noise Abatement Committee meeting; 2) we are moving into certain areas of zoning and land reuse that I feel will be the answer to some of our more acute problems.

We are not going to tell a person that he should move his family because we don't have eminent domain for this particular program. We will have to negotiate with people as we have done in the past. Our total land reuse program, the purchase of homes, is being considered by the Authority. We had a survey of the noise-impacted communities, and they didn't say too many things very kindly about us but they did express themselves as to whether or not they wanted the Port Authority to be the purchaser of last resort.

So I think that there are many things that I would like to rebut, but I think that it should be left that in respect to recommendations, we feel that there should be reasonable standards established for the generation of noise by any vehicle through the Federal Government, and we leave to you the cooperation with the FAA.

We also feel that there is the necessity for greater coordination of the program. I think it is almost time that people looked the noise abatement program squarely in the eye and stopped using Sol Alinsky tactics of sticking their finger in the eye of the biggest fellow in the town and that is how you organize things, realize what the Port Authority's responsibilities are, realize what the State responsibilities are, because if we are not going to have a second major airport in Massachusetts, and it is desired—and if it is desired—then it probably will have to be some other place in New England if the appropriate levels of authority decide that that is what is necessary.

I think, too, that there is developing greater cooperation in the communities, as evidenced by this city planner, who on his own really took upon himself the idea of tackling a very difficult situation with his own City Council and did obtain a certain amount of land on a hill which is not too far below the approach, so that with that type of guidance, which I think the Environmental Protection Agency can provide, looking at a broad spectrum of solutions, determining what the pressures should be, or the standards should be, and suggesting how these alternatives can be considered, can be funded, and implemented. Otherwise we are just going to be back in the same old circus of kicking around the airport operator.

Dr. MEYER. Thank you very much, Mr. Callaghan.

The map that you have furnished and the accompanying information will appear in the record following your testimony.

(The documents above referred to follow in their entirety.)

Dr. **Meyer**. I have several questions I would like to ask before asking the panel if they have any.

First, these rules that are issued by you, as the Noise Abatement Program, are enforced in what manner with the airlines?

Mr. **Callaghan**. Primary enforcement is at night with a mobile vehicle which is operated from 10 o'clock at night to 6:00 o'clock in the morning. We have very few violations. People do call up and say that they are annoyed by maintenance noise, but in my honest opinion most of those complaints can be logically attributed to landings, takeoffs, or taxing. We seldom, although perhaps once a month, we may find somebody who is trying to moonlight to get a plane off in the morning because oftentimes it does delay the takeoffs in the morning.

Dr. **Fidell**. What do you do if you catch some sneaky pilot revving up his engine to take off when he is not supposed to be?

Mr. **Callaghan**. It really isn't the pilot; it is the maintenance crew, and so forth. What we do is to make a report on it, and first I ask the maintenance supervisor what he plans to do about it, and he, knowing that—it isn't so much a matter of fine at an airport. A landlord can just tell you, you better find another airport.

Dr. **Fidell**. Have you ever done that?

Mr. **Callaghan**. Pardon?

Dr. **Fidell**. Have you ever done that?

Mr. **Callaghan**. No, we haven't had the occasion to.

Dr. **Fidell**. Well—

Mr. **Callaghan**. We have—excuse me—we have found cooperation in that I don't think over the past year that there has been more than two or three repetitions by one airline for violation of the night noise abatement emissions.

Dr. **Fidell**. What about all of these others right here?

Dr. **Meyer**. Yes, that is the question I wanted to ask.

I have several questions, if my colleague would yield and let me follow this line of questioning with you.

It has been clearly established in the courts that airport authorities can indeed establish rules and regulations which do not directly interfere with the FAA flight control rules. A lot of the things that I have in front of me are things which clearly fall within that purview.

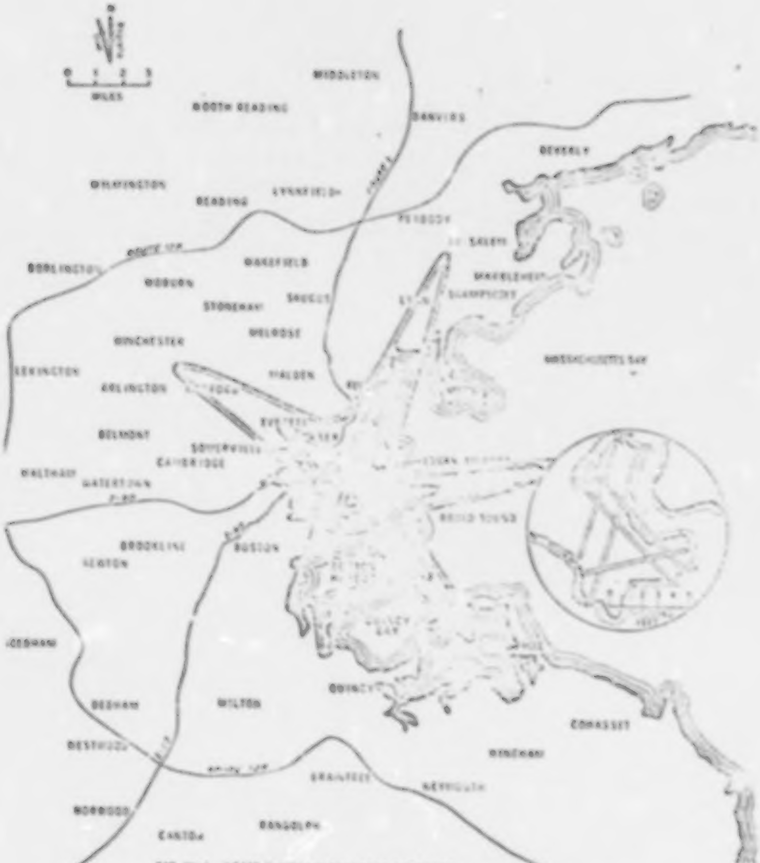
Let me give you an example. Such a thing as flights using other airports for training will take off of Runway 15-R and land 4-R between 11:00 p.m. and 7:00 a.m., and people, of course, have to file clearance.

What measures do you use the check on this sort of thing ?

Mr. **Callaghan**. This is implemented by the air controllers.

Dr. **Meyer**. Are they instructed to report to you, the airport authority, when there is a violation?

Mr. **Callaghan**. They do report on occasion when we have aircraft coming in here from New York. But this measure is a responsibility of the FAA, which has subscribed to the measure,


NORTH
0 1 2 3
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DANVERS
BEVERLY
WILMINGTON
READING
LYNNFIELD
PEABODY
SALEM
BURLINGTON
ROUTE 128
WOBURN
WAKEFIELD
MARBLEHEAD
STONEHAM
SAUGUS
LYNN
SWAMPSCOTT
WINCHESTER
MELROSE
MASSACHUSETTS BAY
LEXINGTON
ARLINGTON
MALDEN
BELMONT
EVERETT
SOMERVILLE
CAMBRIDGE
WALTHAM
WATERTOWN
BROAD SOUND
BROOKLINE
NEWTON
BOSTON
NEEDHAM
QUINCY
DEDHAM
MILTON
COHASSET
WESTWOOD
ROUTE 128
HINGHAM
BRAINTREE
WEYMOUTH
NORWOOD
CANTON
RANDOLPH

FIG. IV-6 NOISE EXPOSURE FORECAST CONTOURS
1967 OPERATIONS
LOGAN INTERNATIONAL AIRPORT
Runway 15L-33R Not Used for [illegible] Operations

TABLE F-12. NUMBER OF AIRCRAFT PRODUCING PEAK NOISE LEVELS IN EXCESS OF 60 dBA

| GRID | DATE 1971 | TIME | | AIRCRAFT DETECTED | | | RUNWAYS IN USE | TOTAL LANDINGS AND TAKEOFFS* |
|---|---|---|---|---|---|---|---|---|
| | | FROM | TO | SOUND LEVEL RANGE (dBA) | | | | |
| | | | | 60-70 | 70-80 | 80-90 | | |
| 1-7 | 3/25 | 0730 | 0816 | 1 | 0 | 0 | 33 | 22 |
| 1-7 | 3/25 | 1132 | 1212 | 2 | 0 | 0 | 33 | 21 |
| 2-4 | 3/19 | 0730 | 0830 | 12 | 4 | 0 | 33 | 31 |
| 2-4 | 3/19 | 1130 | 1230 | 3 | 0 | 0 | 15 & 9 | 27 |
| 2-5 | 3/26 | 0730 | 0830 | 0 | 0 | 0 | 33 | 29 |
| 2-5 | 3/26 | 1130 | 1230 | 0 | 0 | 0 | 33,44,22 | 33 |
| 2-6 | 4/28 | 0735 | 0818 | 1 | 0 | 0 | 4 & 9 | 27 |
| 2-6 | 4/28 | 1135 | 1227 | 0 | 0 | 0 | 15 | 29 |
| 2-7 | 4/28 | 0730 | 0830 | 3 | 0 | 0 | 4 & 9 | 38 |
| 2-7 | 4/28 | 1130 | 1230 | 5 | 0 | 0 | 15 | 33 |
| 3-4 | 4/16 | 0730 | 0830 | 8 | 0 | 0 | 22,27 & 33 | 32 |
| 3-4 | 4/16 | 1130 | 1230 | 7 | 0 | 0 | 22 & 33 | 32 |
| 3-6 | 4/26 | 0735 | 0825 | 5 | 1 | 0 | 22 & 27 | 32 |
| 3-6 | 4/26 | 1135 | 1245 | 3 | 0 | 0 | 4, 9 & 33 | 27 |
| 3-7 | 4/26 | 0730 | 0830 | 3 | 5 | 0 | 22 & 27 | 38 |
| 3-7 | 4-26 | 1137 | 1232 | 1 | 4 | 0 | 4, 9 & 33 | 29 |
| 4-3 | 4/20 | 0734 | 0834 | 8 | 6 | 0 | 4 | 36 |
| 4-3 | 4/20 | 1130 | 1230 | 2 | 0 | 0 | 4 & 9 | 32 |
| | | | | | | | | |
| | | | | | | | | |

*By commercial carriers only.

C-4 are created by highway traffic on the Interstate Route 93 corridor. The relatively high background noise level of Figure C-5 was caused by street traffic on Winthrop Street and local traffic in the high school parking area. Figure C-6 represents a quiet residential area with no through traffic.

### Aircraft Noise

In an effort to identify the effects of aircraft noise on the ambient noise levels in Medford, the measured noise levels during periods in which Runway 33L-15R was in use, at Logan International Airport, were compared with measurements during periods in which the other runways were in use. Runway 33L-15R is directly in line with Medford, and approximately 6.5 statute miles away. Aircraft landing on Runway 15R or taking off on Runway 33L tend to fly near Medford, while those using other Logan runways should approach or leave the Metropolitan Boston area over other sectors. The results of these comparisons are tabulated in Table 8. The measured and calculated values shown in this table were not significantly different for those periods in which Runway 33L-15R was in use as compared with periods in which other runways were in use.

It was noted during analysis of the morning rush hour and midday time history charts (such as those excerpts displayed in Figures C-1 through C-6, Appendix C, described above) that an average of six aircraft per hour were detected with peak noise levels in excess of 60 dBA. A tabulation of these flyovers is contained in Table F-12, Appendix F. Again, on the average, aircraft noise appeared above the background noise level for a period of 90 seconds per flyover (for example, see Figure C-1). Therefore, from these averages, aircraft noise influenced the noise levels in Medford roughly nine minutes per hour, or 15% of the measurement time. This finding would seem to imply that the 10 percentile noise level ($L_{10}$) should be significantly higher for periods of high aircraft activity over Medford (that is, when Runway 33L-15R was in use). The average differences were 1.2 dBA for both the morning rush hour and the midday measurement periods. Further study showed that on the average, 6.0 aircraft per hour exceeded 60 dBA over Medford when runway 33L-15R was in use and that 5.2 aircraft per hour exceeded 60 dBA when other Logan runways were in use. This probably accounts for the small difference in the $L_{10}$ levels shown in Table 8 and further indicates a rather random distribution of aircraft over Medford resulting from operations at Logan regardless of the particular runway in use.

TABLE 8. A COMPARISON OF AVERAGE COMMUNITY NOISE LEVELS
LOGAN RUNWAY 33L/15R - ACTIVE AND NOT ACTIVE

|  | MORNING RUSH HOUR (0730 AM-0830 AM) |  |  |  |  |  | MIDDAY(1130AM-1230 PM) |  |  |  |  |  |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Numerical Average | NO. OF MEAS. PTS. | L10 DBA | L50 DBA | L90 DBA | LNP | RANGE DBA | NO. OF MEAS. PTS. | L10 DBA | L50 DBA | L90 DBA | LNP | RANGE |
| Runway 33L/15R IN Use | 32 | 63.8 | 55.6 | 51.6 | 75.1 | 36 | 27 | 60.7 | 52.0 | 47.4 | 73.1 | 40 |
| Runway 33L/15R NOT in Use | 17 | 62.6 | 53.9 | 50.3 | 72.8 | 33 | 22 | 59.5 | 51.6 | 48.1 | 70.3 | 37 |
| Community Mean* | 49 | 63.4 | 55.0 | 51.1 | 74.3 | 35 | 49 | 60.2 | 51.8 | 47.7 | 71.8 | 39 |

*Average of Values for all locations measured.

## *Logan Airport Noise Abatement Committee*

MEMBERSHIP Airline Pilots' Association Airlines Serving Boston East Boston Community Representative
Federal Aviation Administration Massachusetts Aeronautics Commission Massachusetts Port Authority
Revere Community Representative South Boston Community Representative Winthrop Community Representative

# Noise Abatement Program at Boston-Logan International Airport

Noise abatement at Boston-Logan International Airport is developed cooperatively through the Logan Airport Noise Abatement Committee. It is composed of representatives of the airlines, Airline Pilots Association, East Boston Community, Federal Aviation Administration, Massachusetts Aeronautics Commission, Revere Community, South Boston Community, Winthrop Community, and the Massachusetts Port Authority.

The Committee, including representatives of East Boston, Revere, South Boston, and Winthrop, meets monthly to analyze current problems and suggest improvements. Subcommittees meet periodically. The following procedures are generally directed toward operations of large turbojet aircraft:

1. Logan Airport established the first preferential runway system in the United States. This system influences the use of runways from which takeoffs cause the least community noise.
2. Runups are prohibited between the hours of midnight and 7:00 a.m. A runup is defined as any operation of a stationary aircraft engine above idle power except to overcome inertia to begin taxiing. A night patrol closely monitors this regulation.
3. Prohibition of flights over Boston proper at less than 3,000 feet unless required to do so by Air Traffic Control.
4. Only light planes are permitted to land on Runway 22R, unless safety demands otherwise. Also, a displaced threshold of 800 feet has been established on Runway 22R to require a higher approach slope over the Bayswater Street section of East Boston.
5. A navigational aid five miles north of Runway 22L has been installed to improve approach procedures. A radio beacon permits pilots to remain at 1,500 feet altitude on approach until passing over this point.
6. Aircraft using 22L cross the Whitman check point at 10,000 feet which is 6,000 feet higher than a previous regulation. This change permits pilots to remain at a high altitude as long as possible before descending, with minimum use of power, to the initial approach altitude of 2,000 feet.
7. Pilots awaiting takeoff on Runways 22R, 22L, 27 and 33L are required to point jet aircraft exhaust away from East Boston and Winthrop homes.

8. Air Controllers have been instructed to assign for takeoffs Runway 15R which points in the direction of the open harbor, whenever safety permits, between the hours of 10:00 p.m. and 6:00 a.m.

9. No training practice is allowed on Logan runways between 11:00 p.m. and 7:00 a.m.

10. Flights using other airports for training will, whenever possible, takeoff from Runway 15R and land on Runway 4R or Runway 33L between 11:00 p.m. and 7:00 a.m. to minimize the noise irritation in residential areas.

11. Between midnight and 6:00 a.m., when atmospheric conditions require approaches from the south, Runway 4R is used for landings, rather than Runway 4L, to avoid residential areas of South Boston.

12. On takeoffs from Runway 22R in the direction of South Boston, pilots are required to turn left toward the sea and remain on a heading of 195 degrees for at least two miles from the end of the runway.

13. The full length of the Runway 15R extension is not used on landings. This helps to maintain a higher approach over Neptune Road, East Boston. The runway threshold for landings is displaced 800 feet.

14. Turbo-jets will normally enter the Terminal Area (radius of 30 miles) at or above 10,000 feet MSL.

15. Pilots cleared for visual approach will remain above 3000 feet as long as practicable.

16. Special controls have been instituted in the General Aviation area near Maverick Street, East Boston to minimize night time noise. These include prohibition of runups, positioning of planes to direct engine exhaust smoke away from homes, and the towing of aircraft in and out of hangars.

17. All operators in the North Apron Area have agreed to tow loaded aircraft through the turn on the apron and align for straight-out taxi. This eliminates the application of high power to accomplish short turns.

18. Between the hours of 7:00 a.m. and midnight, any full power runup must be conducted at the Runway 4R dogleg in order to isolate the noise site.

19. If the Night Noise Monitor considers that wind conditions or other circumstances warrant the discontinuance of idling between midnight and 7:00 a.m., he will issue directions which must be followed immediately.

20. No turns will be made on a pull-up, go-around, or missed approach that will result in low and unnecessary flights over surrounding communities.

March, 1971

and the airlines have subscribed to it, and it is left with the FAA to monitor.

Dr. **Meyer.** Then, let me take another example. I think you see the line of reasoning I am following. In Switzerland, which has some very strict rules which apply when airlines persistently violate, the aircraft pilots are required to come before takeoff to the airport proprietor, the manager's office, and receive a complete briefing as to the rules and regulations before they are allowed to clear. Aircraft of airlines which persistently violate their rules are similarly required after landing and a violation has occurred, such as your full length of runway 15-R extension is not used on landings. A similar rule exists at Zurich. If there is a repeated violation reported by their controllers, the pilot is not allowed to leave the airport until he has again been briefed and signed a certificate that he has been so informed. A list of these is promulgated to all of the airlines and is available to the public.

Has any such procedure ever been considered here?

Mr. **Callaghan.** Not in that exact context, no.

Dr. **Meyer.** Do you think it would assist in proving to the public that you are not "insensitive to your responsibilities"?

Mr. **Callaghan.** It probably does have a value. I am glad that you brought it up. We have monitored on occasion the displaced thresholds when people have felt that they weren't being observed. and we have reported to the airlines where there was any violation.

Dr. **Meyer.** Are there any penalties associated with your violation procedures?

Mr. **Callaghan.** No penalties have been invoked as yet.

Dr. **Meyer.** I mean do you have some system set up under the Port Authority, a statute given to it by the legislature whereby you could assess penalties for violations of operational procedures? Does your basic law allow you to do this?

Mr. **Callaghan.** I think that we could assess reasonable penalties, yes.

Dr. **Meyer.** One last question, before asking my colleagues if they have any questions: You mentioned the Noise Abatement Committee, and that you have selected the community representatives. Is this based on statute or is this based on your individual decision?

Mr. **Callaghan.** This is a voluntary association which does not have any place in statutes.

Dr. **Meyer.** So if a citizen's group, such as a Citizens Against Noise from Logan Airport, was formed and petitioned to serve on this Noise Abatement Committee, it would be up to you to decide whether to accept this or not.

Mr. **Callaghan.** Well, we would welcome any additional group representation which is appropriate to our particular function.

Now, as Monsignor Pitaro said, we have sent notices of the meeting to him. We have sent them to other State legislators. The gentleman who represents East Boston, I am sure, is a person who is highly regarded by the Representatives themselves.

There is a Noise Abatement Committee which began in East Boston and Winthrop, but which began to extend itself around the State. But there has been no petition by that group to participate in these meetings.

Dr. **Meyer**. One other thought did occur to me and I would like to ask this, and then I will yield to my colleagues.

Since almost all commercial aircraft operations approaching a major metropolitan air terminal are under air traffic control, and the automated systems which either exist here or will exist indeed identify position, altitude, location, within very precise limits, is there or have there been any discussions with the FAA with regard to reporting of violations of these procedures? The transponder will indicate clearly the aircraft's location.

Mr. **Callaghan**. We have continually brought to the attention of the FAA, through our own monitoring—we send people out into the field, and if we feel as though individuals or even the general conformation is not satisfactory, we report that to the FAA.

As far as transponders, and everything else are concerned, the FAA has the responsibility, and I think we should ask the question to the FAA.

Dr. **Meyer**. Well, my question, sir, was had you attempted to work out an arrangement with them since they do have those flight tracks and can indeed tell an aircraft: "You are 300 feet down and a quarter of a mile left of where you are beginning to approach a prohibited area." The reason I know this to be a fact is that I have been in the cockpit when this has been done.

Have you worked out something where knowing these rules, the rules of the noise abatement program of Boston-Logan International Airport, that they assist you by advising you? Have you approached them on this?

Mr. **Callaghan**. Not in respect to a transponder, doctor.

We have watched the scope, and through the radarscope, they can determine whether a plane is following the appropriate flight track.

Dr. **Meyer**. But you don't have any systematic system where they would just automatically do this?

Mr. **Callaghan**. Not with a transponder.

Dr. **Meyer**. Nor any other—

Mr. **Callaghan**. Well, with a flight track, yes, on radar.

Dr. **Meyer**. All right. Thank you, sir.

I will yield to the colleagues on the left. Question?

Dr. **Whitcomb**. I have one question and then a statement. The question is: Where would the harbor islands be on this NEF map?

Mr. **Callaghan**. They would be out toward the circle.

Dr. **Whitcomb**. How many miles?

Mr. **Callaghan**. About 8 miles.

Dr. **Whitcomb**. Due east?

Mr. **Callaghan**. Six miles perhaps from the airport.

Dr. **Whitcomb**. Due east of the airport?

Mr. **Callaghan**. Yes.

Dr. **Whitcomb**. The statement, then, seeing that you would have a rather extensive set of procedures and rules, and so on, it seems that you have been responsive and yet I am puzzled by the earlier testimony of the lack of responsiveness, and I don't want to get into buttals, rebuttals, and counterrebuttals at this point. But one thing that does seem to stand out, not only here at Logan but in O'Hare and other airports—in fact, one study pointed this up rather dramatically—that one of the most irritating things to a complainant is unresponsiveness or perceived unresponsiveness at least. This turns out to be even more important perhaps than the noise itself, the exposure.

And it seems to me that since you have been making an effort and you are doing things, that a strong recommendation to your group and to airport operators generally would be to have a good public relations program so that people know you are doing what you can within your constraints. And, secondly, there seems to be a rather universal concern over where to lodge a complaint or who has responsibility for this or that aspect of noise abatement and control.

Often it is kind of a buck-passing procedure between the owner of the airport, the FAA, the airlines, and so on. And it seems like it would set better with the residents who are being exposed if this could be avoided whenever possible—this lack of clear definition of responsibility.

Mr. CALLAGHAN. Well, let me try to respond. I appreciate the opportunity.

Number one: Logan Airport is about as close to residential areas as any airport you would find, and no matter how much you may sympathize with an individual, the fact is that in certain neighborhoods, the individual is legitimately, emotionally upset, and the attitude is that the airport operator should do something about it. We are doing what we can within the operational limits of an airport.

Now, if the airport should be someplace else, I think people have to face up to that, and not just consider that the Port Authority is insensitive or hard-hearted.

The other thing which I think is most important is that you have listened to people who are in a political life. The people who have spoken with you and even other people that might speak, represent a thrust in the direction of criticizing the airport operator who has only limited responsibilities, limited authority, and limited power. This is a problem which I submit, gentlemen, Washington hasn't done very much about, and they have responsibities which I submit you gentlemen have to assist.

Once the plane is a foot off the ground, it belongs to the FAA, and if you people can determine what the answer to flight operations, X-number of feet over a house, are, in my opinion, there has to be an accelerated introduction of the new quieter aircraft. I think that it is beginning to solve the problem.

But as was mentioned here earlier, that is a rather slow solution.

Now, we have gone out to Rotary and Kiwanis and Chambers of Commerce, and other groups, and we have explained to them what we are doing. Now, the final thing is that the total community problem in East Boston is being concentrated on the airport. East Boston has many problems, and the people are great people. Certain neighborhoods are really severely affected. But let me just cite a couple of things to give you an idea of the type of community in which the airport exists.

The Boston Redevelopment Authority mad a survey and found out that 40 percent of the people between 20 and 30 years of age left East Boston between 1950 and 1960. They said that something like 80 percent of the housing required considerable repair. They also pointed out that the schools were in poor condition, and so forth.

Now, it is in no sense, and I don't feel as though it could be characterized in any sense other than an ethnically interrelated community which has been ignored over the course of time by people who should have felt a greater responsibility to the community. And then with the airport having a real noise impact on the community, many of the problems of the community are being focused on the Port Authority.

Just let me add: The Port Authority spends $100,000 a year to try to help the community. We spend $35,000 a year for the medical station program in respect to drugs. We spend for various other measures. We have spent a quarter of a million dollars over the past 5 years to try to help the community. But I think that other people, including the city of Boston and other levels of government, have got to help the people, too.

Dr. WHITCOMB. I certainly hope you didn't think I was being critical.

Mr. CALLAGHAN. No.

Dr. WHITCOMB. I was trying to point out that there are steps you might take that you are not currently taking, not in terms of changing the procedures and rules, but in letting people know that you have made this effort to control this. For example, putting this in the newspaper as the measures that are being adopted. And I think it is not unique either to Logan, but it is a rather universal problem of airports around the country.

Mr. CALLAGHAN. I appreciate the suggestion.

Dr. VON GIERKE. I have a question here from the floor, which is pretty close to what I wanted to ask: How do you feel about high speed public transportation to relieve one-third of the traffic into Logan and what steps would you, as the Port Authority, take in incorporating the other appropriate agencies to initiate serious consideration and action on this problem?

Mr. CALLAGHAN. Well, the Governor has already initiated action in a general way. The new Secretary of Transportation through an office of the New England Governor's Conference is exploring possibilities. The Port Authority would be only too happy to participate.

We have written to Secretary Volpe to ask him: 1) whether or not we have an appropriate function; 2) we have told the Governor and the Secretary of Transportation that we would participate in that program in any way that was reasonable at all. So that we are not trying to retain traffic at Logan Airport, but as the airline pilots stated recently, we have the very heavy responsibility of making certain that the airport is as safe as it can humanly be made.

Dr. VON GIERKE. But you mentioned earlier that most of your night traffic is freight operations.

Mr. CALLAGHAN. Most of the takeoffs, doctor, are freight operations.

Dr. von Gierke. And they would not benefit, I assume, from this high speed ground transportation system.

Mr. Callaghan. Well, that is very true, and I see where you are coming back to a previous question. That is true. The New England manufacturer of electronics products, if he is going to hold the inventory, which the wholesaler and retailer wants him to do these days, and deliver it the next morning, he is going to have to have an airport where he can transport to the west coast or transport to Japan or Europe in a very short length of time, and that is going to be air.

Dr. von Gierke. And the last question: Would you consider nighttime curfew under your jurisdiction?

Mr. Callaghan. I really am not qualified to answer that. As the Chairman has said, there has been a good deal of discussion on it. I am not qualified.

Dr. von Gierke. Well, has your committee considered it as one solution to the problem—seriously considered it?

Mr. Callaghan. No, the committee has worked in this fashion: We have attempted to utilize all of the talents—and I estimate that it costs about $1,000 an hour to run the committee when it is in session. We have attempted to utilize all of the experience and background that can be provided by the airport community and by the nearby communities.

We have not gotten into curfew because we consider that a matter of policy and is being threshed out every year in the legislature. We do attempt to utilize what might be called a practical curfew by continually getting the cooperation and bringing any differences to the attention of the chief air controller.

As a matter of fact, we have a law and I require that the log of aircraft operations between midnight and 0800 be sent to me every day, and I check off on it those aircraft that didn't take off from Runway 15-R out over the harbor. And if I note from the wind direction force that they might have done it, I talk to the chief air controller and say, you know, why weren't they off there?

Dr. von Gierke. I guess I asked the wrong question. I didn't mean if the committee considered it, but if the Port Authority is actively pursuing the question of night curfew.

Mr. Callaghan. It has considered it periodically. We have pointed out to some people who mentioned curfews in other areas, such as Washington, that Washington can have a curfew at National and still have their cargo taking off from Dulles. So that we didn't put the airport where it is. We are attempting to operate it for the best interest of Massachusetts and New England, and particularly the people around the airport. We have the utmost sympathy for those people around the airport and we try to do our best for them.

Dr. von Gierke. How much freight is leaving from your Bangor, Maine, airport?

Mr. Callaghan. I understand there are some noise problems up there now. I really don't know just—I really couldn't say. I think maybe some transatlantic might be leaving from up there.

Dr. von Gierke. Thank you.

Dr. **Fidell.** Stuttgart Airport, I believe, in Germany has a continuous noise record available which is capable of identifying discrete noise events of individual flights. Assuming that you had the resources at your disposal to maintain such a system, would you view that as desirable instead of a roving van that goes around at night sometimes?

Mr. **Callaghan.** I plan to get over there shortly, and we have talked to Hewitt Packard and we understand what the operation can do, and I think that it deserves serious consideration.

Dr. **Fidell.** I see. Okay.

Dr. **Meyer.** Well, thank you, sir, for your very candid responses to some rather incisive questions.

At this point, it being 1:20, I will recess this hearing until 2:15, at which point we will have five public witness. I am looking forward to hearing from them all. The meeting stands recessed.

(Noon recess.)

## AFTERNOON SESSION

Dr. **MEYER**. I hereby reconvene the recessed session of the Environmental Protection Agency's hearings on noise abatement and control. I should now like to invite Mr. Charles Schmid, a private citizen, who has some views regarding the noise problem, to come forward.

## STATEMENT OF CHARLES SCHMID, 530 COMMERCIAL STREET, PROVINCETOWN, MASS.

Dr. **MEYER**. Mr. Schmid, thank you for taking the time to join us.

Mr. **SCHMID**. Thank you, Dr. Meyer.

Further, I would like to apologize for my informality. It is kind of warm and I shed my coat.

Dr. **MEYER**. That's all right. If it keeps on getting warmer, we are going to join you by shedding our coats, too, so don't be bothered by that, sir.

Mr. **SCHMID**. I am here as a private citizen very much concerned about the ill effects of aircraft noise pollution on myself and the millions of other defenseless, land-locked, captive audience citizens of this country.

My main objective in this testimony is to prove to you the very acute need for new legislation in order to help protect the physical and mental health of all the people on the ground from this never-ending noise which originates from airplanes and which makes normal living of life and the pursuit of happiness impossible.

As other concerned citizens, I have felt outraged by so much and so many kinds of noise. I have talked to and corresponded with many State and Federal officials during the past few years in my fruitless search for relief from airplane noise pollution. And their answer was like a chorus which said, "Nothing can be done." And it is only because every possible avenue for relief ended in negative results that I am here. After analyzing the reasons for the negative responses, I know something can be done.

And with your help and leadership, it can be done quickly, and the change can be dramatic.

You can effect a major change for the better concerning abatement of noise from airplanes by seeing to it that completely new rules and regulations concerning aircraft levels of flight are written and made the law of the land as quickly as possible. And, one hopes that in the writing of these new aircraft altitude regulations, you will follow the guidelines as stated in the National Environmental Policy Act of 1969, Title 1, Section 101, wherein it says, quote, "Congress declares . . . that it is the continuing policy of the Federal Government . . . to use all practicable means and measures, to create and maintain conditions under which man and nature can exist in productive and pleasing surroundings and attain the widest range of beneficial uses of the environment," unquote.

I knew I would be unable to stay away from this meeting when I read the last part of that Act which says, "Congress recognizes that each person has a responsibility to contribute to the preservation and enhancement of the environment."

My appearance here is the fulfillment of my own sense of responsibility towards trying to contribute to the preservation and enhancement of what is still left of the environment, and the enjoyment of that environment by all the citizens. We hope you gentlemen from the Environmental Protection Agency and the Noise Abatement Office will consider it your responsibility and duty to help us.

Part 91.79, page 10, General Operating and Flight Rules of the Federal Aviation Administration, are, if not the major source of airplane noise pollution, one of the major sources; and this is the section which, for many reasons, should be replaced. Part 91.79, quote:

"Minimum safe altitudes, general: Except when necessary for takeoff or landing, no person may operate an aircraft below the following altitudes:

a) Anywhere:

An altitude allowing, if a power unit fails, an emergency landing without undue hazard to persons or property on the surface.

b) Over Congested Areas:

Over any congested area of a city, town, or settlement, or over any open air assembly of persons, an altitude of 1,000 feet above the highest obstacle within a horizontal radius of 2,000 feet of the aircraft.

c) Over Other Than Congested Areas:

An altitude of 500 feet above the surface, except over open water or sparsely populated areas. In that case, the aircraft may not be operated closer than 500 feet to any person, vessel, or structure."

The most glaring defect, among many, in these 91.79 FAA rules and regulations is, in my opinion, the fact that they are unconstitutional. Why unconstitutional? Because the Constitution gives to every free citizen the inalienable right of self-defense. There is absolutely no way to defend yourself from being slowly but surely destroyed by airplane motor noise from airplanes which these rules allow to fly so dangerously close to us on the ground.

We are, in fact, absolutely defenseless and helpless, and at the complete mercy of these low-flying noise-hawks. And the way I read the Constitution, these laws are unconstitutional.

As far as the human eardrum is involved—and it is indeed involved, plus concerned—allowing airplanes to fly 500 and 1,000 feet above the surface makes no sense whatsoever. Allowing aircraft to fly so legally low may benefit the aircraft pilots, airline industry—although that might be debated—but it is for sure that it does not benefit those of us on the ground in any form, shape, or fashion.

The health and well-being of the people on the surface should have been the motivation for the writing of these rules and regulations of the FAA in the first place. When you make a mistake, you try to correct it, do you not? Well, then, let us say that the FAA Rules and Regulations, Part 91.79, was a 1959 mistake, and that we intend to correct it in 1971. In short, it is time for we millions of people stuck here on the ground to tell the airline owners and aircraft pilots, and all the FAA officials, too: Listen, you guys. You have been getting away with murder all these years and you know it. Now we on the ground are going to make you fly as high in the sky as we think you should fly, and not as low as you think you should fly to us on the ground."

Part (a) contradicts parts (b) and (c). Part (a) conflicts with parts (b) and (c). Part (a) makes sense. And the basic premise that all aircraft flying anywhere had to fly high enough so that if their motors suddenly failed they would be able to make an emergency landing without undue hazard to persons or property on the surface was a fine beginning. Good openers, as it were. It was when, in parts (b) and (c), when attempting to set the lowest altitudes at 1,000 and at 500 feet, that they dropped the ball; or, as the young pollution-conscious generation would say, "They blew it."

Can you tell me where a big or a small plane is going to land if his motors fail why flying 1,000 feet over the middle of Boston, or any other large city or small city, without undue hazard to people and property on the ground? Well, these FAA parts (b) and (c) say that it is safe, for these parts allow all aircraft to fly that low over any city, town, or settlement.

Part (c) is—if you can believe it—even worse than part (b). Part (c) means that when flying in a sparsely populated area, a house here and there, they are allowed to skim the treetops or water except when approaching your house, your kids, your boat or your car; then they must climb up to 500 feet or bank their plane and stay, if possible, 500 feet away—either one or the other. I think it is rather nice that the FAA gives the pilots this choice, for it probably gives us two-to-one odds of not getting killed in our own homes by an airplane.

So, under this part (c), here comes a plane, skimming along the treetops and suddenly, looming up dead-ahead of the pilot, is your house, your kids asleep upstairs. The pilot begins a steep climb or a sharp turn to try to get the required 500 feet away but, at that instant, his motor fails. Where is he going to land? Where else, except right smack-dab on top of your house, where you and your husband are in the living-room entertaining FAA officials who have been assuring you of how safe the FAA rules and regulations are!

Now, this might be a pleasant situation for the FAA officials for, after all, they are saying such low flying is perfectly all right and safe. But, for you and me, I don't think we should go along with them.

I am told FAA used to have a slogan which said, "Keep 'em flying." Well, with the passage of the FAA Act in 1959, they could have added, "Keep 'em flying low."

One cannot help but wonder how this FAA Part 91.79 survived a first draft much less to have been made the law of the land. So, in essence, what we have here in Part 91.79 is someone telling you that you must fly your airplane at all times high enough so that if your motor fails you won't hurt anyone below you, and then, in the same breath, telling you it's safe to fly as low as 1,000 feet over Boston or 500 feet away from people in sparsely populated places. These rules and regulations made no sense when they were written and they make less sense now. And, as stated, they represent a violent abuse of the citizens' rights under our Constitution.

A person's hearing does not have to be especially good in order to be conscious of a plane flying 4,000 or 5,000 feet above them; and under certain climatic conditions, the noise level can be very loud. So, when airplanes are allowed to fly just 500 feet away from you or your house, that is, over or around your house, as is presently allowed, and those planes have from one to four or more propeller-driven engines, the noise is unbearable. And if such flights were allowed to go on and on without letup, which they are allowed to do, it is not too far off base to say that the continual noise could finally kill you. And you can complain to FAA, to your State and Federal officials, congressmen, senators, and governors, and even to the President, but they can do nothing to relieve you or your sense of outrage because all they have to rely on for enforcement is the rules and regulations which I have read to you.

To give you an example of how little the public is protected under these ridiculous FAA rules and regulations concerning safe altitudes of aircraft, I would like to read you a short news item which appeared in the New York Times just a few weeks ago, September 29, 1971, quote:

"Ocean City, Maryland

"The City Council, responding to complaints of 'Noise Pollution' has revoked the landing permit for a popular sightseeing helicopter.

"Residents under the chopper's flight path said the noise from flights, as many as 50 per day, constituted a nuisance."

Can you imagine living under such distressing and intolerable conditions as those people under the path of that sightseeing aircraft? And can you imagine their sense of outrage when they discovered their State nor Federal Government could relieve them of this continual nuisance? And so, at Ocean City, Maryland, the City Council came up with their own unique way to put a stop to such outrageous aircraft flights. I think you must agree that our

Federal airplane rules and regulations should not only have laws with which to stop such airplane harassment and anguish to our citizens but rules and regulations which would never allow such a situation to occur in the first place.

Just last week a plane flying through the Grand Canyon on its sightseeing trip crashed and killed all seven occupants. There are sightseeing planes in Florida, in Arizona, in California, and I am sure the country must be filled with sightseeing planes. And I am also sure that all the thousands of unfortunate people living under the path of all of these sightseeing planes are being harassed and losing their health just as in Ocean City, Maryland.

And we have them down on Cape Cod, too. The airline down there uses a single-engine and several twin-engine planes and, as at Ocean City, Maryland, they fly as close to the ground as possible and as close to the cottages and towns as possible, and sometimes lower; and those planes all have those horribly loud, propeller-driven motors as an extra added attraction for nose-making.

If you think the people under the flight path of that plane in Maryland had it bad, what kind of health do you think you would be in if you were living in those houses down on Cape Cod under the flight path of those sightseeing planes which buzz over the top of the houses 70 to 80 times a day about every 10 minutes, from early in the morning to darkness, 7 days a week, from early April to November, year after year after year?

Complaints are made about the injustices, the harassment, how their homes are unfit to live in due to the horrible noise pollution from the low-flying aircraft, yet they get no relief. FAA officials say that as long as the planes stay close to 500 feet from them, even though such noise is unbearable, that those planes can fly over and around their houses, night and day, forever and ever, and FAA cannot stop them or do anything about it.

In other words, if any of you ladies and gentlemen have a house located in other than a congested area, and an airplane pilot wishes to do so, he can fly over or around your house all day and all night, 365 days a year, year in and year out, and as long as he stays around 500 feet from your house there is not one damned thing you can do to defend yourself as far as present aircraft minimum altitude regulations are concerned—except climb the walls, go nuts, and be consumed with outrage. And the same outrageous situation can exist in Boston, or any city, town, or settlement as long as the planes stay 1,000 feet from you.

I do not think it was the intent of Congress, when they passed the Federal Act of 1959, to allow such abuse of the citizens by aircraft. And I would think you would agree that some immediate corrective action is mandatory. It is difficult to imagine who the writers of this Part 91.79 had in mind when the word "safe" is used. These so-called minimum "safe" altitudes for aircraft are not safe for the people and property on the ground, nor would I think safe for the aircraft pilot and passengers either. It seems to me—and I have talked with airplane pilots—that the fact is, to adhere to these "safe" minimum flying rules is an invitation to disaster.

To eliminate the possibility of such ridiculous situations in the future and to right a wrong and to rid ourselves of a great deal of noise pollution from airplanes which we have mistakingly accepted as a part of our lives, the first positive step to be taken is to throw away the minimum safe altitude flight rules, Part 91.79. Throw it out, lock, stock, and barrel. In its place, make it an iron-bound rule that no aircraft, anytime, anyplace, anywhere, fly lower than 5,000 feet to the surface. Over a city, large or small, or settlement, all aircraft would have to fly 10,000 feet above the surface. Unless airports are equipped to handle jet-driven planes, all aircraft, when landing or taking off, would have to attain the required altitude within a few thousand feet of the runways, perhaps a mile. This would make for easy enforcement and—especially and most important—make it easy for the environment-conscious citizen to report illegal flights.

I contacted FAA's Mr. Harold B. Helstrom, Chief, Airspace and Air Traffic Rules Division, AT-200, Washington, D.C., and he informed me 22 April 1971 that airplanes flying sightseeing trips need not follow any prescribed route. In other words, the pilots can fly over and round anything or anybody all day and all night, if he thinks it might entertain his sightseeing passengers. This would have to be corrected in our new rules and regulations. All aircraft sightseeing operators would have to submit the route over which they intend to fly their sightseeing trips to a citizens' environmental group within a government agency for approval. And only after it had been definitely established that the flight path and route which the sightseeing plane wished to fly was at least 2 miles away from houses, automobiles, people on the ground or boats on the water, would that aircraft be allowed to fly its proposed sightseeing trips.

It would not matter where the people, houses, etc. might be located—be it on top of a mountain, a dune, or in the most remote and isolated place one can imagine—there would just be no exceptions. And, most important, the flight path or route flown by the sightseeing planes, if and when approved, would have to be adhered to as strictly as does an automobile when driving along a highway on the ground. If, after these new laws have been put into effect, and the majority of citizens find that even these new minimum safe altitudes for airplanes are not conducive to their general well being, then, the enforcement agency would push the aircraft higher until that safety level for the people on the ground was reached.

Now, concerning enforcement: To make enforcement as effective as possible, it would seem appropriate for the Environmental Protection Agency to print and publish, at government expense, pamphlets and posters showing silhouettes of different types of aircraft as they should appear to the human eye while flying at 5,000 feet and at 10,000 feet. These pamphlets and posters should be distributed and displayed throughout the land, in front of all government buildings, etc. in such a manner so as to make sure that every citizen will be aware of any airplane flying illegally low. If all the airline executives and airplane pilots realize that the majority of their captive audience down here on the surface knows when he is flying his aircraft illegally and will report him, the chances of his flying illegally low and causing noise pollution will be eliminated.

I would also recommend, and think it advisable, to take the powers of enforcing these new laws away from the Federal Aviation Administration. During the past few years I have discovered that their brand of enforcement is not as concerned with protecting the citizens' rights as it is in representing the views of the airline industry, and I have a large volume of correspondence to prove it.

Mr. Ralph Nader has sometimes ago labeled the Federal Aviation Administration as a moribund agency, and I think he is correct. Since these new laws would be preserving and protecting part of our environment, why not place the enforcement into the hands of a citizens' group which would be a part of your Environmental Protection Agency? This would, it seems to me, place the enforcing powers with people who would truly represent the interest and safety of the people on the ground and not, as now, an agency which seems to represent the airline people. And if not entirely eliminate corruption, white-washes, payoffs, etc. at least keep it to a minimum.

There is no doubt that these recommendations for eliminating airplane noise pollution will bring strong cries of protest from the owners of airplanes and airlines, all of whom have been raping the natural stillness of the air over our heads and exploting our country's natural resources with their manmade noise for all these many years. And, no doubt, they will begin their lobbying, as soon as the word is out that our lawmakers are finally, oh lord, finally, thinking seriously of doing something positive for the citizen concerning abatement of airplane noise pollution. And, of course, the sightseeing people will cry out louder than all, I imagine, complaining that their sightseeing passengers will not be able to see anything on the ground while flying at 5,000 feet above the surface. To which one would reply that if the owners of the sightseeing planes wish for their passengers to see everything on the surface in such fine detail they have only to equip their passengers with binoculars.

Unless we as citizens stand up on our hind legs and let the people in government know what we need and desire in order to survive in this over-polluted world of ours, we will never get the kind of world we need. Airplanes have been flying terribly close to us all these years simply because we as citizens have not made our voices heard in protest. I say here and now, we have suffered long enough. And I would like to ask everyone who is concerned with trying to save our environment, and wishes to stop this never-ending din of airplane noise, we and our families have been subjected to, day in and day out, for lo these many years, to get up on your hind legs, and to join with me, in asking the Council on Environmental Quality, the Environmental Protection Agency, and the Noise Abatement Office, to give us this new legislation, and to make aircraft—all aircraft—fly high enough to where we on the ground, we who are the greatest captive audience in the world are not only not aware of them up there in the sky but to where we may, if we so choose, look up and see them but not hear them.

Thank you very much.

Dr. **MEYER**. Thank you, sir, for a very well thoughtout and ably presented statement.

I would like to ask the panel if they have any questions, and then I have one or two. On my right, Dr. Botsford?

Dr. **BOTSFORD**. No, no questions.

Dr. **FIDELL**. No questions.

Dr. **VON GIERKE**. I just wonder, in proposing a change in the regulation to this extent, I guess you would have to invoke other citizen's rights than just as a right for quiet surrounding.

I assume part of your restriction on sightseeing planes is really more or less for the preservation of privacy, and not so much with respect to noise.

Mr. **SCHMID**. I stated what I had to say here concerning noise. I think it is all said here, I think. It answers your question.

Dr. **VON GIERKE**. Well, I think with respect to noise, per se, you would not necessarily have to restrict circling over a certain area. I think you can be completely quiet and still do this. I mean you would hardly hear anything on the ground.

Mr. **SCHMID**. Flying how high?

Dr. **VON GIERKE**. That depends completely on the aircraft, but certainly in small private craft you wouldn't have to be 5,000 feet high. And you would be, at 5,000 feet, much quieter than any automobile passing your house.

Mr. **SCHMID**. I don't mean to dispute you, but you are entirely wrong. I have had planes flying over me—single engine planes—at 4,000 feet, and the noise—it can be tremendous.

Dr. **VON GIERKE**. It can be.

Mr. **SCHMID**. And it is. It is tremendous.

Dr. **VON GIERKE**. But it does not have to be.

Mr. **SCHMID**. It is tremendous.

Dr. **VON GIERKE**. I just mean either you put the kind of law or regulation on restricting the noise output and then you cannot put it in terms of altitude.

Mr. **SCHMID**. Well, I think your suggestion for putting noise suppressors is great, but let's get this done first, get the planes up there first, and then worry about the noise suppressors, motor suppressors. The first is the most important; the noise suppressors can come later.

Dr. **MEYER**. Don.

Dr. **ELDREDGE**. Nothing.

Dr. **MEYER**. Before you go, sir, I do have a couple of things. First, I agree with you about some of the problems associated with sightseeing aircraft. We have had some studies done on the Grand Canyon that showed both helicopters and aircraft are causing some significant problems.

I would also like to coment—I think one of the things that Dr. von Gierke was—not really disagreeing with you—that it is not only a question of noise but of the physical intrusion of things. Regardles of whether or not they be at 1,000 feet or 3,000 feet, this is sometimes undesirable.

I think the point you made here also of the safety hazard involved in deviating from routes is a good one. The great growth of general aviation has indeed presented a situation in which exposures have changed from what they were when these rules were made. There are more general aviation aircraft flying, and the privacy of people is being affected.

There is one technical point though I think I ought to make, which may or may not have occurred to you. In essence, I agree there is a need for scrutinizing this problem and I intend to communicate with the FAA thereon. But there is one thing I think we need to keep in mind from the total viewpoint of aviation safety. That is that most general aviation aircraft, according to surveys done by the Aerospace Medical Association, and a number of others, are not mandatorily equipped with oxygen equipment. And in certain parts of the United States, 5,000 feet over the surface is about 10,000 feet mean sea level.

Mr. **SCHMID**. Well, there would have to be exceptions here and there. There is no doubt about that.

Dr. **MEYER**. And the net result is certain aircraft would, then, in effect be proscribed unless they carried oxygen equipment because of the problem of anoxia, which is not an insurmountable problem. But I think one needs to keep in mind one's concern with the environment and safety—all aspects of the problem. I just wanted to be sure that the record indicates that that is a problem.

I find that a couple of your comments here about safety—particularly those relating to over water and over remote areas—are those which we in our obligation to the public must indeed again call the attention of the authorities and will, sir.

Mr. **SCHMID**. Thank you.

Dr. **MEYER**. Thank you, sir.

I would like to ask Mr. Desmond McCarthy if he is present, representing the Sierra Club and Friends of the Earth, to come forward.

Mr. McCarthy.

(Discussion off the record.)

Dr. **MEYER**. I am pleased to get an element of the environmental movement in this country to participate. We had a member of the Friends of the Earth serve on our panel in Denver, Mr. Boyd Norton, who was a very able panelist, and whose services I appreciated very much.

## STATEMENT OF DESMOND C. McCARTHY, SIERRA CLUB AND FRIENDS OF THE EARTH, BEDFORD, MASS.

Mr. **MCCARTHY**. My name is Desmond C. McCarthy of 225 North Road, Bedford, Massachusetts. I am testifying on behalf of both the New England Chapter of the Sierra Club and Friends of the Earth.

The topic which I have chosen to speak on is "Noise Emitted by Motorized Vehicles."

There are many sources of noise in our environment, far too many to enumerate in a short presentation. We have singled out one topic which we feel contributes most to the overall noise pollution problem. The topic we have chosen to speak on is the restriction on noise emitted by motorized vehicles.

Air Craft Noise:

Since air craft can be considered as a form of vehicle, we would like to mention them but it is not our intention to pursue the matter since we feel that the subject is adequately covered already. We would merely like to state for the record that we feel they are a vicious form of intrusion into the lives of a large percentage of our people who have to pay the price in annoyance, damage to property, loss of sleep, etc., on behalf of those who operate the aircraft who, on the whole, are a very small percentage of our people of a much more affluent class.

In the case of aircraft we have a classic example of the benefits of a particular technological innovation being reaped by a few while the disadvantages are foisted on the many.

Vehicles and Their Classification:

To return to our topic we would like to outline what we include under the term vehicles. Under vehicles we include all automobiles, trucks, tractors, motorcycles, snowmobiles, trail-bikes, outboard motorized boats, special motorized construction equipment such as front-end loaders, trench diggers, mobile cranes, etc., in fact any motorized device which can be used as a means of transport whether the transport characteristics of the equipment is of a secondary nature or not.

We propose to the panel that this entire field of vehicles be classified for the purpose of noise, into four classes:

Class 1: Light weight motor vehicles or those under 10,000 pounds gross vehicle weight.

Class 2: Heavy motor vehicles or those over 10,000 pounds gross weight.

Class 3: Special motor vehicles or those special purpose vehicles used either for agriculture, construction, emergencies, and some forms of mining.

Class 4: Recreational vehicles or those vehicles whose main function is recreational. It is possible to have in this class vehicles which are functional from both a transportational and a recreational viewpoint. Included in this class are motorcycles, dune-buggies, mini-bikes, trail-bikes, snowmobiles, motor boats, etc.

Noise Levels:

The following noise levels are proposed for the foregoing four classes, for new vehicles. All values are in dB, measured on the "A" scale; measurements taken at 25 feet from centerline of travel and at 75 percent of worst case conditions. We will return to that point a little later on.

You have here before you a table of these values. I don't think we need—

Dr. **Meyer**. But in the record, this will appear just as it is here.

Mr. **McCarthy**. Thank you very much.

| | Light motor vehicles | Heavy motor vehicles | Special motor vehicles | Recreational vehicles |
|---|---|---|---|---|
| Before January 1, 1973 | 80 dB(A) | 85 dB(A) | 85 dB(A) | 80 dB(A) |
| After January 1, 1973 | 75 dB(A) | 80 dB(A) | 80 dB(A) | 70 dB(A) |
| After January 1, 1975 | 70 dB(A) | 75 dB(A) | 75 dB(A) | 65 dB(A) |
| After January 1, 1980 | 65 dB(A) | 70 dB(A) | 75 dB(A) | 60 dB(A) |

The Environmental Impact of Vehicles:

The rate at which American produces automotive vehicles is indeed remarkable. The serious thinker must reflect on the price paid and the services rendered as compared to the total negative impact of the automotive vehicle on our society. Our concern here is noise and this the automotive vehicles produce in large quantities.

There is no conceivable reason why automobiles or trucks should be as noisy as they are. There is no state-of-the-art to be broken through in order to achieve a large noise reduction. All of the requirements are available and can be put to work immediately, if only it were undertaken by the auto manufacturers. This they are not about to do since they feel they have a good thing going and why should they make things more difficult for themselves. In fairness to the auto manufacturers, they are not alone in their approach to problems such as noise. The entire industrial complex has the same attitude. What has to happen, is that these manufacturers must learn that the burdens which they place on the environment are a price which we all must pay and that the true cost of transportation must in the future, reflect these heretofore hidden costs.

Noise is one such pollutant dumped in our environment, and in our opinion a very critical one. Even if the other environmental problems were solved and the noise levels as we have come to know them persisted, they would prevent us from enjoying the other benefits which a healthy environment bestows.

These then are the reasons we place such emphasis on vehicles. They are the greatest source of noise in our society because of their large numbers, the large unattenuated noise sources they posses for power units, the ability to concentrate large numbers of them in relatively small areas such as a street, and our almost total reliance on them for our daily existence.

Engineering Implication of Noisy Vehicles:

What are some of the noise problems posed by the motorized vehicles especially autos or trucks since they are the greatest offenders?

There are at least six major areas of concern:

1. Engine and transmission noise;
2. Exhaust noise;
3. Wind noise;
4. Road contact noise, traction noise or tire noise;
5. Loose body noise;
6. Signaling devices.

Let us look at some of these topics separately a little.

Engine and Transmission Noise:

In an effort to reduce weight of engines and transmissions the auto maker has reduced the wall thickness of the housings. This reduction in wall thickness allows more of the internally produced noise to be radiated out through the walls of the housing. This noise is immediately radiated into the surrounding air and in some cases conveyed into the frame and paneling through the resultant vibration. Other sources of noise are the air intake at the carburetor, and the noise of the cooling fan drawing air through the radiator. This latter noise source increases significantly as the speed of the engine is increased.

Exhaust Noise:

The exhaust noise is well known but some mystique surrounds the muffler and its function. While the muffler serves the obvious function of noise reduction, it is claimed by many midnight mechanics to have a detrimental effect on the back pressure in the engine. Hence, they stay awake nights thinking of how to reduce its impact on their high performance dream child.

Wind Noise:

Wind rushing over, under, around and through an automobile can cause large amounts of noise. This is detrimental to both the driver of the vehicle and the persons outside the vehicle. It would be interesting to see the results of tests for hearing deficiency, if carried out on truck drivers, since they are subject to large amounts of noise over long time spans; especially (wind noise) on long trips.

Road Contact Noise, Traction Noise or Tire Noise:

Road contact noise or tire noise results from a number of things: a) friction; b) tiny vacuums caused by the tire as it deflects in contact with the road surface; and c) the rushing of water as it attempts to get out of the way of the tire.

Loose Body Noise:

Loose body noise is that caused by such things as loose steel tail gates, side panels, etc. which make loud ringing sounds whenever the vehicle goes over a bump.

What can be done about these noise problems?

Almost all noise problems are easiest to solve in the design stage. Many times the noise is indicative of poor design and eliminating the noise can, in many cases, improve the efficiency of the design in question. The application of the noise reduction steps as outlined in noise reduction manuals to automobiles and trucks, would make a vast improvement.

The following points are offered for consideration:

1. Consider the noise problem in the initial design phase of the engine, likewise the transmission and the tires.

2. Construct the body work of the auto or truck to conform to aerodynamics principles instead of the amount of chrome it should carry. This would go a long way in reducing both wind noise and drag, hence improving overall efficiency.

3. Close off the bottom of the engine compartment to: a) streamline the underside and reduce wind noise and drag; b) keep engine noise from escaping; and c) baffle or deflect the incoming and outgoing air so that it performs more efficiently the function it is supposed to do, i.e. cool the engine; d) place a clutch on the cooling fan so that once a given RPM is reached it will not go faster. This would reduce the high pitched noise produced by the same fan at high speeds. And e) use shock mounts for such components as generators, hydraulic pumps, compressors, etc.; and f) use sound reducing material on both the engine walls and the adjacent body work where necessary.

4. Construct more efficient exhaust mufflers which have a greater noise attenuation or design the engine to accept a higher back-pressure which would result from a larger exhaust muffler.

5. Increase the use of noise reduction material inside the passenger compartment.

6. Use only tires whose noise characteristics over the life time of the tire are known to be of low noise values.

7. Design into the bodywork of such vehicles as dump trucks, fastening devices which will hold the gate and panels securely when the trucks are riding empty.

8. Select frequencies for horns, the combinations of which will inform the appropriate parties of each others wishes without producing instant anger, frustration, irritation, etc. The sound level of such devices could most certainly be rduced without their effectiveness as signaling devices being impaired, particularly in cities.

9. The same comments can be made for sirens on police and fire fighting equipment. There is no reason why they should be either so loud and so very irritating.

The preceding discussion is equally applicable to recreational vehicles with some modifications. The basic engineering principles are the same especially concerning the reduction of noise of the engines and absorbing that which cannot be reduced before it is radiated into the atmosphere.

### Recreational Vehicles:

While there are noise problems with trucks, cars and special vehicles, it can be argued that we get a tangible return in work done by these vehicles. We find it hard to apply the same reasoning to recreational vehicles. Here is a class of vehicle which has as its major selling point the amount of noise it can produce. Power is directly equated to noise produced and many who use them get their kicks out of running them at full throttle just to hear the sound, even though that sound is in many instances approaching the threshhold of pain. While the user of the vehicle visualizes that he had the power of a battleship at the touch of his finger, the rest of us must suffer. We are thinking here of motorcycles in particular but the exact same remark applies to snowmobiles and motor boats.

### Snowmobiles:

Because of the functional characteristics of snowmobiles which give them access to the wilderness at a time when nature excludes most others, they can do vast harm. Many species of wildlife use the winter as their breathing season such as the Snowy owl, the great horned owl and many species of hawks. While there are no known studies on the effect of noise on wildlife, some observations have been made on the reaction of trumpeter swans to the noise of air boats. The swans in question abandoned their nest and moved away from the area.

Deer also are known to react violently to such loud noises as emanate from snowmobiles. They can be seen stampeding at the approach of the snowmobile. This stampeding results in much hardship for the animals since in the panic they may try to run through barbed wire fences or get bogged down in deep snow drifts. If the noise limits of the snowmobile were in keeping with the environment in which it operates, then at least some of its negative characteristics would be eliminated.

Motor Boats:

Because of the growing popularity of water skiing and motor boating on our lakes and rivers, the problem of noise in these otherwise serene locations has become appalling. The lake which to some of us was the last retreat, now resounds to the same obnoxious racket as city streets. Since there are no obstructions to deflect or dampen the sound, just one motor boat on a small lake (1 X 2 miles) can cause havoc. These boats, just like the snowmobiles, should have noise limitations placed on them which are in harmony with the environment in which they must operate.

Considerations Affecting the Noise Limits:

Let us now return to the subject of noise limits and why and how they were chosen. First of all we would like to point out that any measurements taken must reflect the operating conditions under which the noise will normally be heard. In the case of all vehicles which operate or could operate on public highways, the distance from the line of travel of the vehicle to the location of the measuring device should not exceed 25 feet. We are aware that many studies in the United States increase the dimension to 50 feet but we are of the opinion that such a figure is absurd when we consider that most of our streets and roads are between 40 and 60 feet wide. An examination of ISO Recommendation R 362 which deals with the topics of Measurement of Noise Emitted by Vehicles, supports this position. They recommend that the distance from centerline of travel to the measuring device be 7.5 meters which is approximately 24 feet, and that the vehicle be accelerated full throttle, in second gear, from points 20 meters apart straddling the measuring device. In other words, 10 meters on the right of the device to 10 meters on the left of the device. We have requested that a compromise between the stationary idle position and the worst case condition or worst mode of operation from a noise point of view be arrived at. We believe that the 75 percent of worst case conditions is a reasonable compromise to reflect normal performance.

Of the limits themselves it is clear to anyone familiar with the subject of noise that they are fair and can be achieved on new vehicles without undue expense. The time limits suggested are also fair since it must be borne in mind that these new vehicles will be with us in ever-increasing numbers for a long time to come.

In conclusion we would like to state that we have attempted in this presentation to place before the panel our views on this very important issue and have offered what we feel are constructive suggestions and ideas which we hope will find their way into the laws governing motorized vehicles at a Federal level. If the respective states wish to impose more stringent requirements they should have the right to do so. In this way we are attempting to bring under control some of the more oppressive aspects of our technological society and to preserve for our children what little we can of what was once known as "America the Beautiful".

Thank you, gentlemen.

Dr. MEYER. Well, thank you, Mr. McCarthy, for summarizing some valuable points regarding what can be done in the views of not only Sierra Club and Friends of the Earth but other sources, and I would like to ask the panel if they have any questions, starting on my left.

Dr. ELDREDGE. Yes, I think you have raised a very interesting point here and one that should be emphasized, and that is that to a certain extent a way of looking at the noise from these vehicles should be interpreted in terms of what residue noise would be in an environment, and here you talked about the contrast between snowmobiles and a quiet snowy scene, which is very much more drastic actually than many other offenders.

Mr. McCARTHY. Yes.

Dr. ELDREDGE. And I think it is worth emphasizing, and that it might be that a noise specification should be even more stringent for such applications than for some others because the contrast is certainly greater.

Mr. McCARTHY. Yes. I feel actually that—for instance, if you take noise measurements wherever we manufacture snowmobiles —factory floor is a typical example—it is a far cry from, you know, 10 miles from nowhere in northern Maine.

I mean there just is no comparison whatever, and this is the kind of thing. It is this serenity of the natural environment which is being absolutely destroyed, and in that kind of an environment, just one snowmobile can be heard for a significant—I won't venture a distance but you know, you can hear it coming from a long way off, and this is what is being destroyed.

We have so little left, we have got to make an attempt to stop what little we have left from being destroyed.

I am sorry to have interrupted you.

Dr. ELDREDGE. Then, I was wondering here, you talk about 75 percent of the worst case. You mean 75 percent power, 75 percent speed, or 75 percent—

Mr. McCARTHY. Whichever produces the most noise—either speed, gearing, acceleration—I don't want to limit that at this particular point, but the point I am making is that if you choose one, okay, somebody else will find probably another which—or could, let me say that—which would probably produce as much noise or more.

Now, I don't want to get into the exact detail of exactly how you do it because I am sure General Motors or somebody else will find a way around that the expense of something else.

Dr. ELDREDGE. And I have one other question that I wondered a little bit why, in this schedule, you have chosen here 5 dB increments for reducing the noise level, and whether you think that that is really realistic. I think people find in general when they go to quieting things that the first 5 dB is pretty easy, and then the next 5 dB gets harder, and the last 5 dB gets to be really pretty fundamental.

Mr. McCARTHY. Yes.

Dr. ELDREDGE. Maybe you have something quite different.

Mr. McCARTHY. No. I am very conscious of that problem and I would say this to you: that that is quite true when you start with a given product as it stands right now and try that technique on it. You have exactly the same problem, and the cost goes up—every dB probably goes up exponentially or close to it. But if you start with the question of noise in the design stage, that is where it is cheap. It is not cheap to quieten something. I don't mean to imply that. It is very expensive to quieten something, after you have to apply it on something that is already designed, and it still ends up being a patched job. But I am implying here on new vehicles this is not such an expense, neither is it such a difficult problem. But one of the major problems that exists is that engineers and designers as a group are simply not conscious of the question of noise. They are conscious of all kinds of other design considerations, but one of the things that must happen is to make this particular group of technical people conscious that they must factor this into their design.

Dr. **Eldredge.** Thank you.

Mr. **McCarthy.** Yes, sir.

Dr. **Whitcomb.** You brought up the point again about local option being important that you could have a blanket Federal law but you might want local option in State or city level to be more stringent. And this morning Dr. Eldredge made an interesting comment, I thought, about the possibility of having relatively more or less restrictive packages of regulations against making noise that a city might be known as a city which would permit only package C, and another State might have C and B permitted as acceptable noise to be made, and then at lunch we were talking about another ramification of this, and that would be perhaps measuring the noise produced by a given truck and then painting a stripe or the cab of the truck in some color so that it would be a truck that could go into zones A, B and C, or only A and B, or only A, because enforcement is a very important part of this whole problem.

Mr. **McCarthy.** I think that would create probably—just responding off the cuff—I think that would create more problems than it would solve. It may deal with the noise problem on paper, but in a practical sense I don't know how effective it would be. It would mean that when we got to the Massachusetts state line, unless it was painted green, red, or yellow, it wasn't going to cross the state line, and that makes no sense at all to me.

Now, what I envision is that a broad approach by the Federal Government to deal with those things which are best dealt with at the Federal level—and you people don't need me to outline those to you; you know them better than I do—this at least is a start. We don't expect that this would be the last word on it. But I feel that what I am frankly afraid of is that because of the pressure politics that are used in Washington, frankly, that the Environmental Protection Agency will not be allowed to do some of the things that it may, in fact, want to do. And that if they are not capable of doing it, I would like to see that at least the option remains open for the States to pick up the challenge as they see fit.

I think this is quite reasonable. I think it is very much in keeping with the American principles, also.

Dr. **Whitcomb.** I think I misled you. I don't want to see you give up the local option that easily either.

You wouldn't probably drive a truck to the state line and then stop and not be permitted to enter the next State, but you would have to restrict your speed perhaps to 30 or 40 miles per hour, because speed and noise is very directly related.

I don't want to get into—

Mr. McCarthy. If I might comment there. At about 65 miles per hour, there is about a 15 dB between trucks and—a truck traveling at 65 and trucks traveling at about 35 miles per hour. This comes out of a highway noise study. But to me that is not the solution. The solution is to—we are not trying to do away with the technological innovations we have. We can't do without them; not for as long as I am able to see. And it just strikes me—it may have its merits, but I don't see it as a way to go. It just doesn't grab me the right way.

I think the thing to do is deal with all vehicles; classify them. That is a very serious problem. Get at least uniform standardization on what we are talking about so that people can talk about them; so that we can have a basis of communication. It is very difficult to do some of these things right now. You see a truck. What kind of a truck? You know, very fundamental things are difficult. And you need this kind of thing if you are going to have meaningful discussion.

Now, I would like to see imposed at a Federal level restrictions on those classifications, and then allow the States to impose greater restrictions, if they so desire it.

But, for instance, if I might comment—to try to be more specific with your question—that, for instance, if there was a general requirement at the Federal level, then, for instance, automobiles registered in the State, for example, they may be required to be quieter on a particular State level. I wouldn't like to just say that, you know, because a certain car comes from New York City it must have that minimum requirement at least. Right now there is none. We can argue what we are going to do afterwards when we get something.

Dr. Whitcomb. One thing I did want to respond to—not a question at all—but you pointed out no known studies on the effect of noise on wildlife with respect to the snowmobile situation. And I think you will be pleased to know that sometime after January the EPA is going to come out with a several volume report on noise pollution, and in that will be a summary of research on wildlife, animals, and so on.

Mr. McCarthy. Thank you very much, sir.

Dr. von Gierke. But as regards this particular study quoted here, this is the first time I hear about this, and that is this EPA draft report, and I would be very interested to get the reference to this study quoted here.

Mr. McCarthy. I don't have the reference to that, and the question about the trumpeter swans—I don't actually have that reference. It was given to me by another member of the Sierra Club, and I will look it up, and I will submit it, if it is of that importance to you.

Dr. von Gierke. Thank you very much.

I am particularly interested in your table, and the time schedule which I think at first glance very realistic, and perhaps, as Dr. Eldredge pointed out, the last 5 dB might come very hard, and I think this might depend somewhat on your definition of the 75 percent worst case condition. I think this is very hard to define, and technically you will have great difficulty defining this. Because, as you know—I mean to define the worst condition, you have to define the road, too. Now, do you define the worst road condition?

Mr. McCarthy. For example, I am thinking in particular as to the manner in which that was set up in the ISO standard. They merely defined it was flat—generally flat area, with no obstructions in the general vicinity in terms that would cause noise reflection—that kind of thing. It merely said to accelerate—they quoted the kinds of vehicles. In other words, manual transmission vehicles that—if they had only four speeds—that it should be run in the second gear.

Dr. von Gierke. Right. But the ISO standard is more or less for type certification, too, and not for the worst condition of all road conditions. That means it does not apply to high speed, and, as we knw, if we go down the list to 1980, when we come to 65 dB(A) or so, you reach the level of tire noise, and that is not considered in the whole ISO standard.

Dr. McCarthy. That is true.

Dr. von Gierke. And, as I said, the road conditions—for example, if the road is wet or not wet—

Mr. McCarthy. Yes.

Dr. von Gierke.—if it is asphalt or concrete—

Mr. McCarthy. Yes.

Dr. von Gierke.—makes a big difference in tire noise.

Mr. McCarthy. It does. But here is the thing—and this, sir, I request you do, if you have not already done it—is take yourself on top of one of the bridges straddling one of our major highways, and see trucks passing 50, 60 miles an hour. Now, I don't mean to say that there is a certain percentage of the noise produced coming from the tires or a certain percentage coming from the engines. There is a God-awful din coming from the engines, transmissions and that. I think it greatly outweighs the tire noise.

Now, what I am suggesting is that if at the design stage some of these considerations are worked in, we will have reduced the problem down to a much more manageable situation.

I agree with you there is a problem of tire noise, as was pointed out in the Anderson report, in New York City, that they made some tests with tires and they found some treads while good when they were new produced whines as they wore down.

Now, I am saying that a little bit of research on that question on the part of the tire people might produce wonders. I am sure if they were told that they had to meet a certain noise standard they would certainly look into the matter.

Dr. Meyer. Would you yield for a moment?

I think I ought to interject something about tire noise at this point.

During the court of the EPA hearings on noise associated with transportation held in Chicago, we received extensive testimony not only from the major automobile manufacturers but also from the major truck manufacturers. It turns out that in addition to the so-called Big Three, a large number of trucks are produced by a segment of the industry called the "heavy truck manufacturers."

I won't mention their names here, but if you just stop and think for a minute, you will think of some well known trade names that are associated with trucks.

We also received testimony from the Rubber Industry Association about work being done on tires. A considerable amount of work on this is being done. It is being done by the Department of Commerce, the National Bureau of Standards. We in the EPA are keeping a close touch with these activities. The Society of Automotive Engineers is also doing a considerable amount of investigation on this. The summation of what I am leading up to is this: It turns out there have been some fairly extensive studies on truck tire noise. As Dr. von Gierke indicated, these studies involve taking a truck and soundproofing it, or sound treating it rather, to such an extent that there is virtually no engine transmission or body noise. You take a special vehicle that has no utility at all as a vehicle other than just providing a propulsion system, and so sound treat it that there is virtually no noise that you can determine at the measurement point from those sources as identified by appropriate octave band analyses. You get that truck up to speed and coast it—I am talking about a heavy truck now—

Mr. **McCarthy**. Yes.

Dr. **Meyer**.—and you coast it. Tire noises from standard type tires which meet the present tire safety requirements are on the order of 65 to 70 dB(A). And this is when a vehicle has no load on it. This is measured at 50 feet. So the problem of tire noise cannot be dismissed quite as lightly as some witnesses—and I am not saying you have dismissed it lightly—because you say you are aware of it—but some witnesses at hearings elsewhere have indicated. This isn't really much of a problem. It happens to be one of the major problems, particularly if you recognize that it has been identified through studies near throughways that the tire noise is the predominant noise where the vehicles are operating at a speed in the vicinity of 60, 65 miles per hour, and rolling along, as they do right around this geographical area, several thousand feet away. That is the noise that you are hearing. So it is not a problem that can be completely dismissed. I didn't infer that you did. I just wanted to get the record, and those who are here might not be familiar with this particular problem to be well aware of the fact that this is a technological problem.

Dr. **von Gierke**. That is just the point I tried to get at. If your table is more or less to be interpreted in terms of the ISO test, I think it would be different from if you want to reach these levels—worst condition at any speed, which would be very difficult, I mean, to even design a test for a high speed operation—

Mr. **McCarthy**. I agree.

Dr. **von Gierke**.—on any type of road.

Mr. **McCarthy**. I agree. But, as in most other instances, I would encourage that a start be made because everything is difficult, you know. As a matter of fact, I honestly feel that there is a psychological problem here with the whole question of noise that hinges around that, is that just because it was a difficult question—and there are a lot of nebulous areas in that as a subject—people just said, well, you know, hands off. Let's leave it. We don't have to confront that problem just now.

So I would say, let's make a start.

**Dr. VON GIERKE.** The California program is a good start. Would you not agree?

**Mr. MCCARTHY.** What is in California doesn't help me in Massachusetts, sir, as I am sure in most of the other States.

**Dr. VON GIERKE.** My final comment is that with respect to recreational vehicles and snowmobiles, you might still be very liberal allowing just 5 dB or less before elevating them on the highways.

**Mr. MCCARTHY.** I am saying that if snowmobiles—all right—that all recreational vehicles—what I am trying to point out here is that all recreational vehicles should be as quiet or quieter than the average automobile, and the demands that ought to be made on the average automobile. I mean that much, I feel, is certainly very true and very desirable. And, again, judging by what we have, it will be a drastically different situation to discuss it if they were at those levels

**Dr. FIDELL.** I have a number of questions and one or two comments.

Since you are presenting testimony here before the EPA, do you propose that the EPA bear the responsibility for implementing the technical recommendations you have made here in the grand scheme of things?

**Mr. MCCARTHY.** I am proposing that legislation concerning the manufacturer of these devices impose this kind of restriction.

**Dr. FIDELL.** Then, you are not specifically saying that you believe that the EPA should be empowered to either impose or in some manner enforce or lobby in favor of this legislation?

**Mr. MCCARTHY.** I feel that they should most certainly lobby in favor of it. I feel that they should most certainly integrate their activities with many of the other Federal agencies including in the question of airport noise and aircraft noise. I mean you are not going to operate in a vacuum, I hope.

**Dr. FIDELL.** But you don't specifically propose that these recommendations would be EPA's responsibility to implement.

**Mr. MCCARTHY.** Sir, I am not very sure how successful the EPA would be in implementing them.

**Dr. MEYER.** Could I interject? Could both the witness and the panelists yield for a minute, please? I must interject one correction here. My distinguished panelist and colleague is not a full-time Federal employee and I must let the record clearly show that Federal agencies are forbidden by law to lobby for any form of legislation.

**Dr. FIDELL.** I am well aware of that.

Let me move off that issue. What is the Sierra Club doing other than presenting testimony of this sort, which I think is highly valuable, to achieve these goals, since the Sierra Club is not restricted by such influences?

**Mr. MCCARTHY.** Like most other environmentally-oriented groups, they are attempting to bring to the public notice, to generally educate both themselves and the public as to what some of these problems are, to bring these problems out into the open, and we would like to see much more done than these people have been doing. But, again, a start has to be made, and they are entirely a volunteer organization who are trying to bring some of these issues before the public.

This is one way of getting some action on them. This kind of activity, you know, probably brought about the foundation of the Noise Abatement Committee in the Environmental Protection Agency.

Dr. **FIDELL.** Are there specific organizations within the Sierra Club or Friends of the Earth which address themselves to noise problems?

Mr. **MCCARTHY.** In California, in Los Angeles, there is a Noise Abatement Committee. I personally would like to see one in just about every city. I feel that is the most effective way of doing things because I think even if you put out wonderful laws and they read wonderful and all the rest, I am not so naive to suppose they can't be gotten around. So it is up to such groups to continuously, let's say, monitor and bring pressure where they can to see that these laws are fulfilled.

Dr. **FIDELL.** I guess there is one point I would like to abstract from your testimony and see if I can get some agreement from you. This morning we heard considerable testimony about injuries done which might be considered within the scope of the common nuisance law, or physical harm done, or more or less readily identifiable causes associated with noise-obstructed instructions.

You seem to be presenting a new argument, and that is for the preservation of the amenities of life, for your life, as it were, to enjoy a quiet wilderness setting. And do you agree that that is somewhat distinct from the sorts of arguments we were hearing this morning?

Mr. **MCCARTHY.** No, sir, I don't. I am only taking what you are saying, since I was not here this morning. I have to work for a living as I am sure you do, too. And we live in an urban society. Most of our people are centered in urban societies. You have just heard, even now—okay—the noise of our technology going zooming by. We can't get away from it within the greater Boston area.

Now, I am saying that we have got to find a way of at least relieving some of our tensions, so that we can at least live in this interim period when we tackle some of these problems. I am not saying that the answer to some of these problems is just going to snap your fingers and you are going to come up with it—obviously, no.

But the point is we must survive in the interim. What I am proposing here is merely a start. I am not suggesting that it is the end-all of anything. But if we have environmental wilderness regions and lakes—I am thinking distinctly about one night I spent on a lake in New Hampshire—a most beautiful night. And somebody just came along with a motorboat and, man, it blew it completely.

Dr. **FIDELL.** I think perhaps that was the point I was trying to make.

Mr. **MCCARTHY.** But it is not disassociated from it. For instance, the average people who live in the city are subjected to a very high noise volume continuously on a long-term basis. It is at least a help for their sanity and well being if they can get someplace to go out even just for a rest. I am saying that that escape hatch is rapidly diminishing and closing down.

**Dr. Fidell.** I have no further questions.

**Dr. Meyer.** Do you have a question?

**Dr. Botsford.** I have a question, Mr. McCarthy, about your table of proposed limits.

I wonder if there is a typographical error in it. Take, for example, the special motor vehicle category. You call for no reduction in the last time period, whereas you do for all other categories of vehicle. Is that a mistake?

**Mr. McCarthy.** No, sir, it is not a mistake.

**Dr. Botsford.** Also, in the last column, in the first time period, you call for a 10 decibel reduction, whereas in the other vehicle classes you call for 5. Is that a mistake?

**Mr. McCarthy.** No, sir, it is not a mistake.

**Dr. Botsford.** All right.

Two comments: I think that what happens in California does help you in Massachusetts, and me in Pennsylvania, in a way, because I know for a fact that General Motors makes one car that they could sell in my State, and so when California sets noise standards that require noise abatement in Chevrolets, let's say, we all benefit from it. Maybe you weren't aware of that.

**Mr. McCarthy.** No, I am aware of that.

**Dr. Botsford.** All right.

**Mr. McCarthy.** And I am not saying that the States aren't free of blame in this either.

**Dr. Botsford.** One other comment about tires. One of the noisiest truck tires, I understand, is a retreaded tire, and it is because of the peculiar tread design in these molds that are used for retreading, and they are all over the country, and it is the one that produces the penetrating whine that is so familiar.

Now, that is an economic decision; that is a decision to retread, which I think certainly is open to question and correction.

Another thing I sort of am reluctant to mention is that the studded snow tire has introduced tire noise in the automotive vehicle picture where it really wasn't present to a great extent before, and I think it is a wonderful invention and I would hate to see them go. But there, again, you have a choice which increases noise.

**Mr. McCarthy.** You also have—in a situation with a studded snow tire, you have a somewhat modified environment. You have usually a winter environment where more people are indoors. You may have a snow cover—in these States you have quite a snow cover—and I would also bring to your attention that with such things as snow tires, there ought to be a speed limit where such tires exist. As a matter of fact, I believe there are in some States because if you had one of those studs or spikes come flying out, you know, it must be just as bad as being hit by a bullet out of a cannon.

**Dr. Botsford.** I don't know of any States where there is a speed limit for studded tires. Some States prohibit them because they are bad for the road but—

No further questions.

**Dr. Meyer.** Well, first, I would like to thank you for producing a very stimulating discussion with the panel. I would like also to thank you for noting, as I had noted several times today, the problem of the intrusion into this environment of warning devices. These warning devices, I am told by the industry, have to be like this because of the noise which exists from transportation and other sources. Most people now drive with their windows up and, therefore, you have to have the warning device loud enough so everybody can hear them. This is an interesting commentary on how things escalate from one point to another and the whole problem gets much worse as we go.

I would also like to make a comment though that we in the Environmental Protection Agency are increasingly concerned with the fact that there is a urban environment that needs protection, and there is an urban ecology which needs consideration. I would hope that we, at some point, working from the Federal level with the States and cities, could change the situation with regard to a place where almost 80 percent of our population now lives so that you don't say we are just trying to endure it, but instead that we are living in it and enjoying it just as much as the rural environment.

Mr. McCarthy. I endorse those sentiments very much since I have lived in cities most of my life.

Dr. Meyer. Well, thank you, sir, for producing the discussion that you did, which was characteristics of the way that the Sierra Club and Friends of the Earth have operated, and I appreciate it.

Mr. McCarthy. Thank you very much for your time and interest.

Dr. Meyer. At this point, I am asked by Senator Kennedy to read a statement into the record, which I shall now do. This is from Senator Edward M. Kennedy of Massachusetts, and I shall read it for the Senator as requested by him and his staff.

## STATEMENT OF THE HONORABLE EDWARD M. KENNEDY, U.S. SENATOR, STATE OF MASSACHUSETTS, WASHINGTON, D. C.

### (AS READ BY DR. ALVIN MEYER, JR.)

Dr. Meyer. "I am happy to have this opportunity to put forward my views on the noise problem that plagues the citizens of Massachusetts. I am certain that this distinguished group of panelists and witnesses over the next 2 days will gather valuable scientific and technical data and advance possible solutions to overcome our noise pollution. All of us will benefit from the dissemination of the information and data obtained at this hearing.

"The problem of noise in our environment is another of those ironic situations in which the solution to the problem is readily available. But the solution is costly, so the problem continues to grow. While the communities raise the level of protest, the noise problem increases and compounds itself. While new technology to reduce noise goes wasted and unused, new vehicles and appliances producing greater noise appear on the market.

"Noise from aircraft increases and impinges even deeper into the community, while noise abatement procedures fail to reduce noise impact significantly and soundproofing and air conditioning are not included in a total noise abatement program. Airport growth and expansion surrounding major cities continues over the protests from the neighboring residents, while joint scheduling and routing are not permitted. And deafening jet noise continues.

"Noise from automobiles, trucks, and buses continues to abuse citizens living near major thoroughfares, while new noise-abating devices, friction dampening, quieter tires, and highway improvements to provide quieter roads are not part of our highway development program. Roads are built to accommodate even more noise producers and they are built near urban and suburban population centers. And the horns continue to blare.

"Subway noise still deafens the residents of some American cities while quiet rubber-tired subway cars remain tourist attractions for Americans in cities such as Montreal or Paris. And in the name of progress, demolition and construction sites blot every population center and blue the environment with noise. Household appliances not only increase in type and style but also in velocity. So what is not done to us on the outside, we do to ourselves in our homes because our purchase choices are limited.

"We have made some progress in recent years. Research by the Federal Council for Science and Technology, and National Aeronautics and Space Administration, and funding by Federal agencies into noise abatement research has been extensive in the last 4 years. The Department of Transportation has been responsible for the Interagency Aircraft Noise Abatement Program. Both the Department of Defense and Health, Education, and Welfare have sponsored occupational noise research. The National Bureau of Standards has worked on architectural acoustics; the Department of Housing and Urban Development has worked on noise control in residential housing; and the Highway Research Board and Bureau of Public Roads on traffic noise abatement.

"Recent legislative efforts are the result of increased public awareness of the noise problem. The Aircraft Noise Abatement Act of 1968 and Title IV of the Clean Air Act, the Noise Pollution and Abatement Act of 1970 which provided $30 million for the study of the effects of noise pollution, both are major steps in a total noise abatement program. On December 1, 1969, the Federal Aviation Administration instituted the first set of aircraft noise restrictions on all future aircraft. And in 1969 we saw the institution of regulations in occupational noise exposure under the Walsh-Healy Act.

"But in the area of noise abatement, we are for the most part trying to undo existing damage and limit the implications of future harm from noise. After too many noisy planes were in the air, we got standards for future models. As NASA pointed out in its study, there has been insufficient economic incentives, inadequate Federal response to manufacturers and operators to develop new technology for achieving meaningful noise abatement.

'We now have suitable, inexpensive air conditioning on the market, but it has not been installed as part of a subsidy that airport neighbors are entitled to. New and effective soundproofing techniques are available but school children near airports have not seen any benefit of these.

"In this community of Boston, we have an excellent example of community response and local leadership at odds with airport expansion and jet noise. The residents of East Boston, Revere, and Winthrop have protested aircraft noise over the years and have had some success in halting the current expansion program, but why is it necessary that they flight for a tolerable noise level for their families?

"And at some level within government and at the university level, we must begin to bring the acoustical physicist and the psychologist and physician together in an expansive research program to measure the effects of noise on human beings.

"The Noise Exposure Forecast developed by Bolt, Beranek and Newman has done much to describe the noise impact on individuals, but further qualifying measurements are needed. At hearings in February 1968 here in East Boston, I took up the problem of noise pollution which resulted in this major noise measurement study. After the release of Bolt, Beranek and Newman study, we held another hearing in East Boston in December 1969 to seek implementation of its findings.

"But methods of measuring the human response to noise which take into account the special effects of impulsive noise, multiple-diverse noise events, and noise which interrupts sleep and conversation and work must be established. When I traveled to Winthrop and East Boston last year, I heard the stories of people whose sleep and conversations were interrupted constantly by the roar and rumble of jets, the reports of hospital patients who could not sleep, the complaints of citizens whose roofs are so close to the flight paths that their children cannot safely fly kites. I have sat in school auditoriums where I could not hear my own voice each time a jet flew over.

"We now know that permanent hearing loss can result from exposure to high noise levels. But we do not know how to measure and to what extent noise plays a part in anxiety, social conflict, or physical problems such as high blood pressure or heart disease.

"While we do know that reactions to noise are not determined to any significant degree by age, sex, or social status, we do not know why some people get used to a noise, others do not; why some feel certain sounds are tolerable, others disagree.

"I hope that this hearing will demonstrate what direction we should take in the future to provide an adequate noise abatement program. I believe that we will need, first, a comprehensive government research and development program into the nature and cause of noise, adequate measuring devices and techniques, as well as noise abatement procedures. This research and development should cover under one directed effort the noise problems in transportation, construction equipment, and home appliances. The recent announcement that the Department of Transportation and NASA will have a joint Office of Noise Abatement is an encouraging sign in this direction and I would hope that the excellent facility in Cambridge, Massachusetts, would be utilized in this effort.

"Most importantly, further research should have as its basis the determination of psychological and physical effects of noise on human beings. Secondly, we must have strong Federal standards of noise abatement in the construction equipment and appliance industries as well as the transportation industry. Air and rail and highway traffic is interstate, and it seems to me the need for Federal regulations is clear. If we are to begin a massive effort to control and preserve our environment, I think minimal Federal standards are the first step in all of these industries. Of course, local communities should be consulted at every step during both the research and promulgation of standards. Thirdly, I believe all research and development, standards, and enforcement within the government should be under the direction of a single agency, the Environmental Protection Agency. While diverse research projects carried out by various governmental agencies in the past have contributed to our overall effort, I think a single, direct response through the agency of government best equipped is what is required now.

"While there is little question that technology will have to be redirected, there is no question that this is the simplest aspect of the solution. No one doubts we are able to make things quieter, only how badly do we want to, and how much are we willing to pay. Quiet may be costly, but the price of noise is one we cannot afford to pay."

End of the statement by the Senator. The Agency appreciates it very much and will take due notice of his comments and recommendations.

I think that his challenge to the professional community is rather clear. Because it is a good statement of interest, I will want to see to it that the colleagues of the various professions that are here tomorrow have a chance to review it.

At this point, it is 5 minutes to 4:00. I am going to declare a 5-minute ecology recess before proceeding with the rest of our several witnesses who are here.

(Short recess.)

Dr. **MEYER**. After that brief recess, we will reconvene.

Is Mr. Jerry Falbo of the Masachusetts Air Pollution Noise Abatement Committee here? Mr. Falbo? If Mr. Falbo comes in, we will move to him at that point.

Is Mr. Allen Morgan of the Masachusets Audubon Society here?

All right. Is Mr. John Regan, Chairman of the Faculty Senate of the Barnes Junior High Schol here? Mr. Regan, would you kindly come up and join the panel and give us your views? Proceed, sir.

## STATEMENT OF JOHN M. REGAN, CHAIRMAN, FACULTY SENATE, BARNES JUNIOR HIGH SCHOOL, EAST BOSTON, MASS.

Mr. **REGAN**. Those of us who go into East Boston in the morning are certainly aware that there is a major environmental difference between it and our home areas, be they other parts of the city, the rolling hills of Dover or the manicured lawns of Belmont. The noise that the part-time resident encounters is often deafening, and the specter of incoming planes flying so low over houses and streets that one can distinguish faces at the planes' windows is rather frightening. If, however, one goes to a soundproof office, especially at the airport itself, which incidentally is less noisy than areas under the flight patterns, then the noise and closeness of the planes are easily adapted to and forgotten. If one goes to East Boston homes or schools, the story is entirely different.

On relatively calm days, such as we had yesterday, all goes swimmingly. People are good humored; buildings do not tremble; windows don't rattle; no one is inordinately nervous or jumpy. In school, a 45-minute class is 45 minutes of learning and teaching. When I began to teach in East Boston, days like yesterday were the rule; now they are the exception.

In 1971, a typical school day is marked by the roar of planes taking off over our heads, the nerve-racking sensation that the building is shaking and the partial or total lack of communication for various lengths of time. Mornings are worst. All too frequently class has to stop completely. Today things were pretty bad, but our worst day to date was October 19, one week ago yesterday. On that day few of us managed to conduct even a semblance of a class during the second period, 9:25 to 10:10 a.m. In one 10-minute stretch, 10 jets, one per minute—we counted them, it was all one could do—screeched their way over the school. That the presence of such noise makes understanding of words, let alone thoughts, impossible is well documented in the book "The Effects of Noise on Man" by Karl D. Kryter, the newly-elected president of the prestigious Acoustical Society of America. It might be pertinent to state here that our school lies under a secondary flight pattern. Schools like East Boston High and the Kennedy and Sheridan elementary schools lie under primary flight patterns and their problems are ours multiplied.

East Boston is not the only town being abused by noise pollution. Winthrop and South Boston have always suffered. More recently Dochester, Revere, and Cambridge have had severe problems. Indeed, the inauguration of M.I.T.'s new president was almost ruined when the inaugural address was interrupted so often by passing planes that vast sections of the audience were unable to understand the speech being delivered. The longstanding problems to tens of thousands has rapidly become an immediate problem of hundreds of thousands. East Boston is, however, the only community which suffers the dual problem of ear-splitting noise and the machinations of the autonomous Massachusetts Port Authority. If one is an East Bostonian, autonomous M.P.A. should read unethical, dictatorial, insensitive, self-aggrandizing, deceitful M.P.A.

Are there specific physiological and psychological problems that are directly attributable to noise pollution and which I have observed in more than a decade's teaching in an environment which has suffered an ever-increasing level of airport-related noise problems? The answer is assuredly "les" to both kinds of problems.

To begin with, East Boston's school children have the highest percentage of failures in the city-wide hearing tests. Admittedly these tests are group tests and are therefore suspect. However, the testing is done the same way throughout the city, as easily wrong in one area as in another, and yet year after year, East Boston youngsters fail them in ever-increasing percentages. A higher percentage of our youngsters are called back for individual hearing tests than in any other area. We can see only one explanation: hearing is being systematically damaged by noise pollution.

Many of our students speak in abnormally loud tones. Frequently they yell when they are attempting to converse with you or to make a point in class. The M.P.A.'s public relations people like to ascribe this phenomena to the extroverted Latin temperament, over-emotional Italians, etc. As I find myself yelling back—this is, mind you, only normal conversation—I wonder what the explanation is. I doubt that I have become Latin by osmosis; it's not fighting fire with fire. What has happened is that reacting to the noise of planes we have all developed the habit of yelling, even when there is no need, because we fear of not being heard and some of us have suffered ear damage.

The yelling too often becomes physical. One yells loud enough, long enough, without hearing all that's being said, and fights result. Fights between students in school were rare occurrences. Lately the increase has been dramatic. In the past 3 or 4 weeks, we have experienced a rash of these brawls. After they are broken up and the kids are asked for reasons, they have none or they reply that they feel nervous or jumpy that day. These incidents always occur when the first two periods have been heavily interrupted by planes taking off over us. When the flight patterns change, and we are placed in the direct route, a direct change in students' behavior patterns results.

Nervousness, nerve-related belligerent attitudes, ear damage, and communications disabilities are some of the physiological problems we teachers observe in our students.

What I have said is based on a survey of the faculty in my building, the junior high school, and on-the-spot check of faculty senate members at the senior high school and the two elementary schools previously mentioned.

The following questions were asked of 35 teachers in my buildings:

1. Have you ever had to stop teaching because of airplane noise: Answer: 34, yes; 1, no. And incidentally the one "no" was an art teacher who said that she didn't need group discussion. She had kids working on individual projects so there was no interruption.

2. Have you lost appreciable amounts of teaching time because of airplane noise? Answer: 33, yes; 2, no.

3. Have you noticed abnormal behavior in students that you believe is noise-induced? Answer: 33, yes; 2 no.

4. Would you say that the noise problem is dramatically increasing; increasing; unchanging; decreasing? Answer 33, dramatically increasing; 2, increasing; 0, unchanging; 0, decreasing.

Several teachers added comments that they had written complaining letters to the Port Authority, the Army Corps of Engineers and the various newspapers but had never received even a reply from anyone. One teacher summed up rather neatly. In the survey, under "decreasing," she wrote, "Are you kidding?"

Serious though they are, these problems are minimal compared to the psychological damage to your youngsters in the past decade and a half or so. This damage is the result of noise combined with the policies of the M.P.A. The damage is not yet irreparable, but close to it.

Consider the meaning and the psychological effects upon all of us, but upon children especially, of the following occurrences:

1. The crash of a Northeast Airlines plane in the fall of 1963, I believe, in the Orient Heights section of East Boston. Thousands of us witnessed the removal of bodies from the wreckage and speculated that if the plane had been a few degrees different in course, it would have torn through the densely populated Heights or Day Square areas.

2. The continual land grabs and threatened use of eminent domain powers by the M.P.A. all through the 1960's. There is a curiously significant way of dating things in East Boston. People talk in "the time of . . ."—the time of the Northeast crash; the time of the Amerina playground; the time of Neptune Road; the time the Maverick Street mothers were beaten by the State Police; and, most unhappily, the time of Wood Island Park. These weren't happy times—an accident; a demonstration by parents whose children's playground had been seized forcing the children to play in the street and the State Police were called out to break up mothers who had blocked the street with themselves and their children; and three massive, some contend illegal, land grabs.

What, I ask you, are the ramifications of a community's dating itself by its perceived disasters?

What happens to the stability and security people need when the live in fear of their homes being a runway or a terminal a year from now? And what happens to childrens' minds developed in such a crisis atmosphere? Childrens' first memory is often of being awakened by noise and shaking, crying, and being comforted by parents who explain, "It's just the planes." Many of our children can't sleep properly. Deprivation of satisfying sleep obviously affects behavior.

3. East Boston's cynicism is of incomprehensible magnitude. Much of it is the result of the people's experience with the M.P.A., experiences that have been detrimental to the town's self-image. A few examples of what I consider the Authority's psychological warfare against East Boston are these:

a. The Port claims that it does all it can to eliminate noise. Yet 2 years ago when Senator Kennedy held hearings in our school's auditorium concerning noise and airport expansion, there were few planes passing over during the day. Next day we were back to normal. A moment ago he commented that even then it was a problem and that it slowed it down. The running joke was that the Kennedys should move back to East Boston, where the family originates, and maybe we would have some quiet.

b. When the Massachusetts Port Authority's Mr. Callaghan comes to local meetings, the results are occasionally ironic, always damaging. I remember two meetings in particular. Mr. Callaghan informed us that land takings were over. Within a week, the time of Neptune Road began and we discovered the Port had purchased the Transitron property in East Boston. On another occasion while Mr. Callaghan was explaining that the planes were an inconvenience, nothing more, he was totally drowned out several times by jets roaring over the high school in which we were meeting. It was funny, but it illustrates the basic problem of our lives. No one is secure because no one knows the truth and the Port isn't telling.

c. Once it was rumored that some buildings were to be soundproofed in a Federal experiment. Great! The high school, we thought, or the two elementary schools, or perhaps the two old people's homes in the area. Wrong. We don't know if anything was ever done but the standard comment was: "Probably the motel and the Tower of Logan." Defeatism and cynicism at their height! Is such a chronic state of suspicion, passivity and cynicism a positive psychological attitude? Is defensive apathy an attitude our society hopes to cultivate?

Drs. Kimball of Duke University and Garmezy of the University of Minnesota, in a book called "Principles of General Psychology," state that constant stress results in an increase in deviant behavior. Even B. F. Skinner's critics agree with him that one is a product of his environment. Skinner maintains that man's external environment forms and controls his behavior, which brings us to the problems that are recognized in general as the town's worst: community apathy, noise pollution, drug abuse, and vandalism. These are parts of our environment which are all interrelated and result in part or in whole from the existence of the airport and its irresponsible independence.

I shudder, but I understand such comments from pillars of the working class as: "The only thing wrong with the college kids is that they're bombing the wrong places." And, "How come the government lets them do this to us?"

Yes, the psychological damage has been extreme. The disenchantment with the government is overwhelming because what really is, is just too different from how the "American Dream" says it is supposed to be. Is the "American Dream" the "American Lie"? How many more tens of thousands can the country afford to lose to the ranks of the disenchanted? Saving East Boston, its way of life, and the minds of its young people—even attempting to do so—might start healing some of the damage, some of the innumerable problems.

Thank you.

Dr. **Meyer**. Thank you very much for presenting one of the few documented surveys with regard to school children and teacher attitudes; and also for presenting a very forthright discussion of the problem as seen from your viewpoint.

And I have a couple of points I would like to make, but I will start now on my left with the panel because they are all interested in this very phenomenon that you are discussing.

Dr. Eldredge, do you have anything?

Dr. **Eldredge**. Yes. You report that children are being forced to have repeat audiograms or measurements of their hearing.

Mr. **Regan**. Right.

Dr. **Eldredge**. More often in this—

Mr. **Regan**. No, not more often, but that more numbers are called back for individual tests.

Dr. **ELDREDGE**. Do you have the numbers which say, then, out of those that are called back, how many of those actually had a hearing loss?

Mr. **REGAN**. To be perfectly frank, I could have perhaps drawn those statistics together, but I only got word of this business over the weekend and, you know, I did the best I could with what I had.

Dr. **ELDREDGE**. Numbers such as these would be very helpful if they can be dug out of the record.

Mr. **REGAN**. What I did was get in touch with the school nurse to verify, you know, is it so or not? And she said, "Yes, it is so."

I said, "Have you any figures available?"

She said, "No, I haven't."

Dr. **WHITCOMB**. To continue with what Don was saying, numbers and degree of hearing loss in the East Boston school children would be of interest particularly when compared with nonnoise-impacted schools.

Mr. **REGAN**. All right.

Dr. **WHITCOMB**. Perhaps similar socioeconomic levels, if you can get that.

Mr. **REGAN**. Right. I also had in mind, we are quite convinced—good numbers of us—that our barbiturate problem particularly is related to it; perhaps a look for quiet or escape from the noise, and so on.

I wasn't aware that we could make proposals but I think that Health, Education, and Welfare might look into perhaps getting a similar community socioeconomically and then have somebody study drug problems from that point of view as well as its hearing problem.

Dr. **WHITCOMB**. Secondly, did you, at any time, happen to get a sound level meter into one of the classrooms?

Mr. **REGAN**. No, I am sorry. We have had no scientific equipment.

Dr. **WHITCOMB**. That's unfortunate, because from what you are describing it seems like the level must be extremely high.

Mr. **REAGAN**. Well, it's brutal. I minded it particularly today. We really have minimal—that is what is so amazing—our problems are minimal compared to the three other schools that I mentioned. The high school—it is too bad Senator Kennedy's Boston page who delivered his speech didn't stay. He was a student of mine 2 years ago. He is at the high school now and the building actually trembles, and trembles most of the day, you know, which he could have verified. He could just tell you what it is like to be in the situation like that as a student.

Dr. **MEYER**. It seems to me we are going to have to get several other locations like this come in and make some direct measurements of this acoustical problem.

Mr. **REGAN**. Yes.

Dr. **VON GIERKE**. Has this problem of potential hearing loss to children been entered in the court suit against the aircraft noise?

Mr. **REGAN**. I couldn't say. (Aside) Do you know? No, not that we know of.

Dr. **FIDELL**. I have no questions.

Dr. **MEYER**. Jim.

Dr. **BOTSFORD**. I have a question about the hearing test.

Mr. **REGAN**. Yes.

Dr. **BOTSFORD**. The fact that more children failed the screening test in your area than in other schools.

Mr. **REGAN**. Yes.

Dr. **BOTSFORD**. Of course, in a hearing test, you are trying to determine the faintest sound that a person can hear.

Mr. **REGAN**. Yes.

Dr. **BOTSFORD**. And this depends on their hearing ability, but it also depends on the ambient noise which will mask out these faint tones.

Mr. **REGAN**. Yes.

Dr. **BOTSFORD**. Now, I wonder if that factor was looked into and determined to be not the control factor since you do report—

Mr. **REGAN**. To be candid, I doubt that it has even been looked into. I know that those tests are administered under regular school circumstances and they are administered with the same equipment, you know, that travels sort of city-wide.

When our building is shaking and the planes are roaring over us they are roaring over the medical building room as well.

Dr. **BOTSFORD**. I think you may have a problem there then.

Mr. **REGAN**. Oh, have we ever.

Dr. **MEYER**. There is one interesting point that I want to be sure is reflected in the record, Mr. Regan. It is that in connection with the numerous investigations made about community reactions to noise, one thing that is often said is: Well, the people who complain the most are upper middle class citizens from an affluent society.

And this particular piece of paper doesn't seem to indicate that that necessarily is so, if I read the description of this area correctly.

Mr. **REGAN**. No, it is what we call a working class area predominantly. Unfortunately what you say is more correct.

They complain. They don't know how to act frequently in groups. They don't have the sophistication or the techniques often. They are very suspicious and cynical. They feel—many of them—that their community is doomed and there is no point, and the best thing to do is just not to get involved and not to care. It is like a pall of doom that hangs over the place.

Lately it has been changing. I will admit lately there have been more and more people getting active, and that is why we have sort of an optimistic outlook for the very first time, you know, in well over a decade.

Dr. **MEYER**. Well, this information that you are just giving is very important to us in assessing the extent of the noise problem because, as I said, we have heard many times: Well, only the people who are well off are the ones who really feel they are affected.

It is obvious from what you are telling us that it may not be—

Mr. **REGAN**. Oh, no, it is felt. It perhaps isn't expressed as well as somebody who might have a better command of the media or the economics or the language.

Dr. **MEYER**. Any other questions or comments?

Yes, go ahead.

Dr. **FIDELL.** I just might point out: They don't live there, do they?

Mr. **REGAN.** True.

Dr. **FIDELL.** The people of whom you are speaking who might be able to complain don't live there.

Mr. **REGAN.** Right.

Dr. **MEYER.** Thank you very much, sir, for a very important paper.

Again, I would like to see if Mr. Falbo is here, or Mr. Morgan of the Audubon Society.

Mr. Morgan, would you like to come forward, sir.

## STATEMENT OF ALLEN H. MORGAN, EXECUTIVE VICE PRESIDENT, MASSACHUSETTS AUDUBON SOCIETY, LINCOLN, MASS.

Mr. **MORGAN.** Thank you, gentlemen. I am sorry that my remarks are going to be very general in comparison to the previous speaker who was very impressive.

My name is Allen Morgan, and I am Executive Vice President of the Massachusetts Audubon Society, a nonprofit conservation organization of just over 23,000 members whose concern includes the quality of the human environment.

A recent statement in the press that noise in America now increases at a rate of one additional decibel each year rather surprised me. I thought it was increasing at a faster pace. My own experience with noise certainly indicates: 1) that in the communities with which I am familiar, the decibel increase has exceeded an additional 10 points in the past decade; 2) that at some point in the last decade, noise passed a threshold that has turned a once minor nuisance into a major source of concern.

Many of the problems with which conservation organizations must deal are masked from public perception. For instance, the passage of chlorinated hydrocarbons through ecosystems, or the presence of damaging chemicals in water that appears crystal clear. These require clinical demonstration, laboratory analysis and/or sophisticated explanations. But noise wears no mask. Each of us is aware of its existence and I am certain that none would deny its proliferation, although as it creeps slowly upward over a period of decades, the usual conservation dilemma is repeated once again: as an insignificant act is multiplied by 10, by 100, by 1,000, or 100,000, at what point does insignificant become significant and finally emerge as serious and finally catastrophic?

I shall not attempt to discuss the physical and emotional price which I am certain that humans pay for the noise now inflicted upon them from sources that lie beyond their control. I know that I myself often pay the price of lost working time which amounts to hours in the course of a year. I know that many persons in this room can give similar testimony. I also know that I pay a price physically from noise abuse. It is true that I never have been tested on a sophisticated electronic machine which might measure my losses of efficiency to noise and therefore cannot furnish for you now a proper graph detailing its loss. Nevertheless, as a human, I know that the loss exists, and I know that others in the room are equally aware of such stress.

Until recent years, noise was considered an urban problem. The defenders of noise could advise one to leave the city and escape the torment of their products. But the growing popularity of snowmobiles, all-terrain vehicles, snowblowers, power lawnmowers, chain saws, the incessant parade of airliners overhead, the roar and whine of tires and engines, and grating of gears from throughways, have brought a constant background bedlam of decibels to the suburbs—indeed, into the open countryside everywhere. In addition, residents in both city and country inflict upon themselves—courtesy of unwitting or indifferent manufacturers—an unmanageable amount of noise through the use of vacuum cleaners, dishwashers, and similar modern appliances.

As a biologist—or at least a person with broad biological training—I know that the human ear and nervous system evolved to serve man at a noise level which by today's standards would seem a hushed silence. As an organism with such an evolutionary history, I have a birthright for a quieter environment. So does every other human. Yet the fact is that few of us are ever privileged to experience it for more than the briefest interlude.

The only hope of achieving a lower level of noise, it would appear, is Federal intervention. I have been assured by engineers that quieter machines are possible. In fact, some engineers say that many machines are designed purposely to emit more noise. In these instances, at least, noise is a sales gimmick—an outlet through which some men seem actually to achieve some magic increase of masculinity through the extra roar of his automobile or motorcycle exhaust, or the housewife be assured of the power of her vacuum cleaner. The Federal Government, through its regulation of interstate commerce, could provide standards that would subdue such noise. The only loss will be of the noise itself, to everyone's great gain.

In some instances, changes in operating procedures can reduce noise levels. Needless noise has been reduced at many airports through changes in traffic patterns and in modifying takeoff and landing procedures. There certainly must be other areas of human endeavor where rather simple changes in procedure would modify the noise volume.

What we must clearly recognize is that there is a limit to human endurance of noise. It is my hope that this hearing and later hearings will begin shaping guidelines that will result in noise abatement. If these guidelines are imposed at a Federal level, all manufacturers will have equal knowledge of what is expected in their fields and have an equal opportunity of meeting those standards. I don't see how it can be done at the State level.

It was my good fortune to spend a week several years ago at a wilderness campsite in the subarctic, 40 miles from the nearest human habitation, 300 miles from real civilization. The lack of noise was profound, and made an indelible impression upon me, for as the wind stopped I experienced real silence for the first time in many years. It is impossible to experience silence in Massachusetts today other than by earplugs. Coupled with darkness—real darkness—another impossibility in the out-of-doors today here, it was a profound experience and one which if ever achievable again here in Massachusetts in a very subtle but real way will be of benefit to us all.

Thank you very much.

Dr. **MEYER.** Thank you, sir.

Dr. Eldredge.

Dr. **ELDREDGE.** No.

Dr. **MEYER.** The panel all agree with your statement very much and appreciate your making it, sir.

Mr. **MORGAN.** I apologize for the platitudes. I wish I were an expert.

Dr. **MEYER.** No, I think it is a very well said point, particularly about the quiet which very few people seem can find anywhere today.

Mr. **MORGAN.** This isn't the subject, but the combination of quiet and darkness after dark in the subartic is unbelievable, and the brilliance and closeness of the stars. You can't see stars in East Boston today frankly.

Dr. **MEYER.** That is part of the problem of our combined environmental stresses, I might say.

Mr. **MORGAN.** Do you want these? (handing Dr. Meyer printed matter)

Dr. **MEYER.** Yes, sir, please. We would like to have those for the record. (That material follows on next three pages.)

At this point, then, I should like to ask Dr. Robert Cunitz, Psychologist, to speak. He is appearing on his own behalf, as I understand it, sir.

## STATEMENT OF DR. ROBERT J. CUNITZ, PSYCHOLOGIST, NATIONAL BUREAU OF STANDARDS, GAITHERSBURG, MD.

Dr. **CUNITZ.** Dr. Meyer, gentlemen. I want to thank you for the opportunity to speak to you today, and I want to preface my testimony by saying that my remarks should be taken as coming from an individual concerned scientist who has dabbled in the field of human response to noise for the last 3 or 4 years, and not as a representative of the National Bureau of Standards, the agency for which I work.

And before I start, I also wish to acknowledge the contribution which Mrs. Elizabeth Quadra, of your staff—who is now a member of your staff—has made to my thinking about the noise problems over the last number of years, and indeed her contribution to my testimony today.

Environmental noise is a problem which has been growing gradually over the years, and because of its insidious and nonfatal nature has attracted relatively little public attention as an environmental pollutant until recent times. As a result of the lack of public pressure and the general lack of knowledge about the effects of noise on people and available preventive measures, very little has been done—at least in this country—to stem the tide of more noise, and noise in more places.

The magnitude of the noise levels to which American citizens are exposed has grown significantly over the last 30 years and projections indicate a continuation of this rise. Noise is also spreading geographically into remote outdoor recreational areas

# NOISE
## POLLUTION

### FOUR DEFINITIONS

**NOISE** — unwanted sound. Luckily, with noise two-plus-two does not equal four. Ten motorcycles are not ten times as noisy as one motorcycle but twice as noisy.

**DECIBEL** — the unit of measuring the loudness (intensity) of a sound. Zero on the decibel scale is the slightest sound that can be heard by the best ears and so weak that it moves the eardrum one-tenth the diameter of a hydrogen atom. The scale goes up logarithmically, the perceived loudness approximately doubling every ten decibels. Since the blast of a jet engine at takeoff can reach 150 decibels — 1,000,000,000,000,000 times as intense as the threshold of sound — the human ability to hear anything from rustling leaves to a jet blast makes the ear like a balance which can weigh anything from a postage stamp to an ocean liner.

**PITCH** — tone level. Pitch is determined by how many times per second the sound waves vibrate. The lowest note on a piano has a frequency of 30 cycles per second; conversation ranges between 200 and 6000 cycles; and a "silent" dog whistle gets up to 14,000 cycles. The high-frequency noises that we can hear seem louder to us and are more disturbing, decibel for decibel, than low-frequency noises.

**SONIC BOOM** — the loud bang and change in air pressure of the shock wave which every plane flying faster than the speed of sound (about 700 miles per hour) drags along behind it. The boom isn't a one-time nuisance, occurring only at the precise moment the plane crosses from sonic to supersonic speeds, but follows along behind the plane for the entire duration of the supersonic trip.

### DECIBEL SCALE

| | |
|---|---|
| EARDRUM RUPTURES 140 | jet taking off |
| PAINFUL TO EAR 120 | siren<br>jet revving its engine for takeoff — [illegible]<br>roar of a [illegible] prop plane |
| DEAFENING 100 | thunder<br>car horn at 3 feet — loud motorcycle<br>loud power lawn mower |
| VERY LOUD 80 | portable sander<br>have to shout to be heard<br>food blender<br>continued daily exposure brings about loss of hearing<br>noisy cocktail party<br>impossible to use telephone |
| LOUD 60 | city playground<br>vacuum cleaner<br>noisy office<br>average traffic<br>point at which use of the telephone becomes difficult |
| MODERATE 40 | suburban playground<br>all right for a restaurant<br>average living-room |
| FAINT 20 | quiet enough for courtroom or classroom<br>private office<br>a whisper at 5 feet |
| THRESHOLD OF AUDIBILITY 0 | rustling leaves<br>breathing |

NOISE is a true environmental pollutant. Like air and water pollution it damages our health and lowers the quality of our life. In Europe the malignant effects of noise on the total environment are well recognized. In Sweden, for example, the State Power Board's one-year course in pollution control trains engineers to deal with water, air, and noise problems. Here, we are barely beginning to realize what a growing menace noise pollution is and that it must be curbed.

### HOW NOISE AFFECTS US

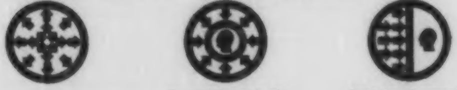
Reactions to noise are more subjective than they are to smog or a drink of polluted water. About a fourth of the population say they are not disturbed by any noise, however loud; these are the people who should live near airports. One in ten is hypersensitive, but because he dislikes almost any noise not of his own making, his complaints are ignored. In between come the rest of us, and we are more sensitive to noise on some days than others. In general we find high-pitched noises harder to take than low, and any noise sounds twice as loud at night.

The most specific effects of noise are on hearing. A loud blast such as an explosion deafens everyone momentarily. (At the same time it arouses an "alarm" reaction so primitive and automatic that even newborn infants cry out with terror.)

Permanent hearing loss comes only from repeated or continuous exposures. Everyone agrees that an eight-hour daily exposure to 80 or 85 decibels leads to severe hearing damage. Until recently this was thought to be the only damaging effect of noise on the ears. But doctors now suspect that our high community noise level — traffic in morning and afternoon and TV at night with occasional additions from police sirens, planes overhead, car horns, and vacuum cleaners — helps account for the deafness of older people in all industrial countries and especially in ours.

Noise has other measurable effects. It raises blood pressure, lowers efficiency, and triggers ailments like stomach ulcers and allergies. It is the main cause of loss of sleep. The World Health Organization says it can be harmful even when it is not consciously heard. Dr. Vern O. Knudsen of the University of California sums it up as "a slow agent of death." And, as a matter of fact, 160 decibels — only a few more than the sound of many jet planes at takeoff — is lethal to mice and similar small animals.

THE THREE BASIC WAYS TO COPE WITH A NOISE PROBLEM



Surround the noise source with sound-absorbing material.

Surround the people who would be disturbed by the noise with sound-absorbing material.

Install a sound suppression device between the people and the noise source.

COURTESY OF [illegible]

## WHAT WE CAN DO ABOUT NOISE POLLUTION

Noise IS pollution. And the United States is the noisiest country in the world and getting noisier.

The background din of modern life comes from machines. Noisy power lawn mowers and motorcycles generate levels of loudness formerly found only in boiler factories. American kitchens with three or four appliances operating at once have been clocked at 100 or more decibels. We also have long exposures to air-conditioners (often 70 or 80 decibels), city traffic (with a mean average of 78 decibels at a Boston school playground during recess) and all-day drives (which leave most people with a temporary loss of hearing).

Since the machines are here to stay, what can we do about the noise?

We can begin by making better use of the mechanical mufflers and other silencers we already have. The Paris and Montreal subways are equipped with rubber-tired wheels, and ours could be too.

Actually, most noise nuisances can be controlled by new devices. Among recent American inventions are a "silent residential quality" attachment for pneumatic drills, steel mesh blankets to muffle blasting, a quieter pile driver, and even a portable ground muffler for jet planes to reduce sound during warm-up periods. Acoustical engineers, who can build quiet motels in the middle of airports, know all the techniques for sound-proofing buildings, from what kind of partition makes the best sound barrier to how to mount apartment doorbells so that the only ring you hear is your own.

The din of traffic, rated in one large survey as more annoying than all other noises put together, can be reduced with the improved mufflers now available for all vehicles including trucks and motorcycles. New materials have been developed to make quieter road surfaces, and there are even quieter tires.

The rewards of a quieter environment need more publicity. They are much commoner than most businesses and individuals realize. It is no accident that of the four main centers of noise pollution (industry, airports, traffic, and buildings), the noisy industries have made the best progress in solving their noise problems. They began to worry about noise in 1948 when a New York worker won the first damage claim for loss of hearing acquired on the job. Now that claims amount to $2 million a year, noise abatement gets serious attention.

Practical incentives exist for builders too. In New York City some new high-rise apartments are unprofitably empty because of internal noisiness. And in the suburbs sound-conditioned houses sell faster than similar houses without anti-noise features even though they cost several hundred dollars more.

Noise abatement pays in many other businesses. Studies at Colgate University showed that the average worker spends one-fifth of his energy fighting noise. When the noise level drops, output goes up and absences and employee turnover drop.

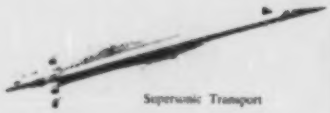
When incentives are lacking, noise control laws and regulations must take over. Julius Caesar originated the legal approach to the quieter life by banning night chariot-driving in the streets of Rome. His example is followed today by every country in northern Europe from Britain to the USSR. European noise-abatement regulations include acoustical building codes, local ordinances forbidding the use of motorcycles during sleeping hours, and even national laws forbidding transistor radios in public places.

In comparison, we have no federal noise-abatement laws, very few state laws, and nothing more helpful on the local level than ordinances against disturbing the peace. Typically, the peace can be disturbed only after 11 P.M. and then only by a noise nuisance coming from a nearby home.

The final and most important weapon against noise pollution is public pressure. For years the people who live near airports have been writing their Congressmen, signing petitions, and attending hearings by the busload to make their objections to the racket known. They sue the government for loss in real estate values and incite their public schools to sue the airports for impairing education. They have made the airport noise problem so notorious that towns unite instantly to keep proposed airports as far from their borders as possible. And while airports are still very noisy, they would be much noisier if public pressure had not forced the aircraft industry to spend millions of dollars a year on noise-control research and the federal government to regulate flight patterns and even set up noise limits at night.

If nothing is done about noise pollution, in ten years our environment will be twice as noisy as it is today.

Do we want that?



Supersonic Transport

> "It's not enough to win yesterday's battles. There are new forces at work we must be ready to contend with. The sonic boom, in my judgment, is one of the most serious ones . . . you cannot make out a case against the sonic boom by damage to the frail historic places nor, probably damage to wildlife. But you can make out a case in terms of damage to man's habitat . . ."
>
> Stewart L. Udall

## HOUSE LOTS & NOISY STREETS

There are several ways of mitigating the noise nuisance, says Dr. Robert B. Newman of Bolt, Beranek, and Newman, the country's leading research and consultant firm in acoustics.

Q. Will it help to plant a barrier of trees and shrubs between the house and street?

A. Not at all as far as sound is concerned. Of course, if your house is separated from the highway by 900 to 1000 feet of thick deciduous woods, you will get more traffic noise in the winter when the leaves are gone, but this isn't a typical city or suburban situation. A barrier to keep out sound must be bulky and solid like an earth embankment or even a tall apartment house — trees won't do.

However, there's a lot of psychology in how we react to noise so trees, shrubs, and fences do have a function. They act as a visual barrier — out of sight, out of mind.

Q. Can an existing house be soundproofed?

A. Double windows on the street side will keep out some street noise; carpets, draperies, and acoustic tile will subdue the reverberations inside. The open layout of much modern architecture is an enemy of quiet in itself. The front rooms of a house on a noisy street should be segregated from the back with solid doors and floor-to-ceiling partitions, and then the back at least will be quiet.

It sometimes helps to provide a constant subdued background sound like a quiet fan, air-conditioner, or soft music which will mask out the annoying noises. But as with [illegible]me, the masking technique has its limits — up to about 35 decibels which is still barely noticeable.

Q. The outdoor living area should obviously be located behind the house, away from the street. But should it be put near the house or at the far end of the lot?

A. Near the house. Sound barriers do a better job either close to the source or close to the hearer than halfway between.

It takes more distance than most people realize for sound to fade away. And when the noise comes from a constant line of moving traffic instead of a single source, it takes a greater distance for the sound to drop as much. This is one reason why people living in the country are bothered by night-time traffic on highways miles away. Another reason is that natural country sounds are too low to do any masking, say 30 decibels even when the crickets are singing.

Q. Can anything be done to mask sounds outdoors?

A. Try two or three little fountains or an artificial waterfall. The sound of running water is an ideal masking noise. It is continuous and unobtrusive, it carries no information, and it has pleasant associations for almost everyone.

## SONIC BOOMS

With sonic booms the worst is yet to come. When — and if — Boeing's supersonic transports (SST's) crisscross the country, millions of Americans every day will jump with alarm, feel the house shake, and hear the windows rattle. From time to time they will watch plaster crack and fall and will sweep up shattered glass. And this is the *least* in the way of annoyance and property damage that we can expect from the SST.

Any plane flying faster than the speed of sound trails behind it the cone of noise pollution called the sonic boom. Although the bangs only last a fraction of a second, they usually come in pairs and are as loud as a medium-sized explosion in the next block.

A few years ago the U. S. government decided to find out exactly how annoying they are. Every day for five months Oklahoma City was jarred with eight sonic booms a day, none of high intensity and never at night. A poll taken after the test was over showed that the bang startled, disturbed, and annoyed almost everyone living within eight miles of the center line of the boom path.

Property damage is caused by the sudden change in air pressure that accompanies the boom. Two booms a week for a few weeks from the Air Force's new twin-jet spy plane over Los Angeles drew 504 damage claims, mostly for window and plaster damage. Jury awards have been as high as $10,000 (for an Oklahoma City house which was virtually split in two by the sonic boom tests).

Protest groups like The Citizens League Against the Sonic Boom (11 Appleton St., Cambridge, Mass.) are being organized here and there but on the whole Americans take the boom nuisance more meekly than Europeans. Sweden and other countries are considering forbidding any supersonic flights over their territory. The British flood their newspapers with angry protests. The French have been especially successful in getting cash settlements. In 1965 the French authorities paid more than a quarter of a million dollars for boom damages and immediately tightened flight rules, even to banning all supersonic flights over metropolitan areas. Yet one year later the number of damage claims almost doubled and settlements for the single area around the base of a new supersonic bomber approached $400,000.

Today's supersonic planes are all military. The first SST's, the Anglo-French Concorde and the Russian TU-144, are expected to begin delivering cargoes as well as booms in 1971. The Boeing 2707 is scheduled for a few years later. A law of physics says, the bigger the plane, the bigger the boom. The Boeing SST will be longer and wider than a football field and by far the largest supersonic plane in existence. Even when it is flying at 60,000 feet it will produce on the ground a boom covering a belt twice as wide and almost twice as intense as the Oklahoma City booms.

But until the Boeing monster comes along, the place to write for damage claim forms is the U. S. Air Force.

where Americans go to escape from the pressures and stresses of urban life. In the following, the degree and extent of the community noise problem will be pointed out and some thoughts on a comprehensive approach to noise prevention, noise reduction, and noise research will be discussed—if I may be so presumptuous.

## THE PROBLEM OF ENVIRONMENTAL NOISE

Noise, of course, may be defined as unwanted sound. As an environmental problem, it is increasing steadily in urban areas and is spreading rapidly into suburban, rural, and wilderness areas where, 10 years ago, it was not even thought of as a problem. This increase in the environmental noise problem is directly attributable to the proliferation and geographical spreading of machines, industry, transportation, and people.

Dr. Vern Knudsen, acoustician and Chancellor-Emeritus of UCLA, has stated that community noise is increasing at a decibel a year and has done so for the past 30 years. This assessment is certainly borne out by some comparative measurements in the same communities separated by the 12 years from 1954 to 1966.

In addition to increasing in intensity, noise as a problem is rapidly spreading geographically. Aircraft noise is no longer confined to the airport interface. A recent study in California has shown that unless better planning of airport sites and adoption of noise-minimization flight corridors occur, by 1990 the entire Los Angeles basin will be blanketed by noise levels and frequencies of occurrence now experienced only in the vicinity of airports. Reports are circulated by Sierra Club and Seattle Mountaineers members of diesel truck noise heard at the top of Mount Rainier, 14,410 feet above sea level and 40 miles from the nearest truck highway. Another major factor in the spread of noise is the recent increase in the use of recreational vehicles such as the motorcycle, minibike, dune-buggy, snowmobile and all-terrain-vehicle.

## ENVIRONMENTAL NOISE: THE HUMAN EFFECT

There is much yet to be learned about the real cause-effect relationships between each environmental pollutant and long-term physical and mental health. This statement is particularly true of noise. However, such people as Robert Finch, past Secretary of HEW, has stated: "It is clear that excessive and needless noise constitutes a nuisance at best, a health hazard at worst. It is an impediment to intangible human values." And Dr. Roger Egebert, an Assistant Secretary of HEW, has made the prediction that noise will become our number one health problem by the turn of the century. Many health authorities have become personally convinced that noise is a public health hazard when it occurs with the intensity and pervasiveness found in much of our urban environment today.

There is even more to this issue if one considers "health" as a condition which encompasses something more than merely the absence of disease. The definition of health propounded by the World Health Organization is more realistic in this age of frustration and protest: "Health is a total state of physical, mental and emotional well-being, and not merely the absence of disease." The adoption of this viewpoint will cause one to consider here and now the implementation of policies and programs designed to reduce noise in our daily lives and will cause one to institute the research programs necessary to discover the nature of the cause-effect relationships which surely exists between noise and "health."

Adopting the World Health Organization's definition, what are the known effects of noise on health? These effects take many forms ranging from physiological damage in the form of permanent hearing loss to interference with speech and learning, to physiological stress reactions, to disturbance of sleep, and to sociological effects both within and without the family. Almost all of these effects are directly related to the intensity and total exposure time of individuals to noise. For example, it takes a very high noise intensity and repetitive exposure to cause permanent hearing loss, while a much lower noise can disturb sleep, impede communication or lead to the psychological and sociological side-effects which have only recently been identified. The remaining effects of noise are related to semantic content, e.g., all apartment dwellers are well aware of the inhibiting effect of having little or no acoustical privacy due to the minimal attenuation provided by most dwelling unit walls.

Some of these effects, particularly the noise-induced hearing loss and interference with speech communication, are well documented while others have been studied only in a few scattered laboratory experiments, i.e., the physiological stress and sleep disturbance effects. And the sociological and psychological effects are only beginning to be qualitatively observed in a few field studies. Furthermore, new effects are constantly being discovered, such as the effects of a mother's noise exposure on her unborn foetus and the child's postnatal development, and apparent effects of extreme noise environments upon the mental health of exposed populations.

It is unlikely that noise has ever killed anyone directly, except for one or two accidents associated with rocket test firings. However, occasional press reports do cite incidents involving shooting and killing a neighbor or a neighbor's child "for making too much noise." There is even the report of a Japanese mother in Osaka—suffering from Meniere's disease—who threw her children down a well and herself after them because of the intense pain caused her by jet aircraft landing at Osaka's airport. A "Donora" for noise is unlikely to occur; however, the insidious effects of noise will, if unabated, continue to afflict the lives and welfare of thousands, unbeknown to them, unless major efforts are made to reduce the severity of this problem.

The difficult part of the noise problem is that most people in adverse noise situations have no idea that noise is affecting them. Thus, most industrial workers in the process of suffering a noise-induced hearing loss are unaware of their hearing deficit, do not believe it when they are warned, and will refuse to use protecting ear coverings. Recent press awareness of the relationship between hard rock discotheque "music" and teenage hearing damage further illustrates this point. Studies of the effects of low level noise on human sleep have shown that sleep can be disturbed, i.e., the sleeper can go from a deeper stage to a lighter stage of sleep without the individual being aware of the disturbance; he only knows the next morning he is tired and irritable. And levels of noise which induce measurable physiological stress reactions continue to do so after many years of exposure even though the subjects themselves are unaware that noise is having any effect on them. The insidious nature of noise as a stressor is one of the primary reasons why we cannot expect the individual citizen to protect himself against exposure.

## POSSIBLE SOLUTIONS

Our goal must be one of securing health for the people by prevention rather than by treatment of symptoms. To do this, we must achieve a "designed environment" in which noise is limited below values which are harmful to good health—and here I used the World Health Organization definition. It will be useful to consider a comprehensive, although simple, three-part model while determining the necessary course of action. This model consists of a noise source, a receiver—in this case, a human being—and the propagation path between the noise source and the receiver.

The function of the "receiver" in this model is to set limits; we cannot change people but we can design their environment to fit their needs. Such design requires a foreknowledge of these human needs. This knowledge can only be obtained through a comprehensive research program designed to look at the characteristics of the receiver, i.e., what and how much noise can be tolerated by an individual in all circumstances of his life. Decreasing the amount of noise that arrives at the receiver can be done in several ways: provide attenuation in the propagation path and/or reduce the noise levels emanated by the noise source. The most economical solution to this aspect of the problem will probably be a combination of actions that give attention to all possible avenues, rather than an effort into one of them alone. Any such solutions involve cost, both economic and social. Environmental constraints must be economically and socially viable, implying a cost-benefit analysis of all proposed solutions.

What, then, should be the role of the Environmental Protection Agency in providing solutions to the problems documented above? It is clear to me, at least, that EPA should concern itself with all aspects of the noise problem. Specifically, the Agency should be involved in the basic research necessary to set the human design limits. We must find out what we need to know through a combination of in-house and contract and grant research. Primary attention should be directed towards those areas where our knowledge is minimal, i.e., noise-induced physiological stress, sleep disturbance and the social-psychological implications of noise exposure in different settings: home, work, recreational areas, and so on.

The Environmental Protection Agency must also be involved in attempts to control the other two aspects of the problem. Specifically, we should be supporting an R & D effort designed to provide the American public with quieter machines and transportation systems—both vehicles and roadways; we should also be looking into methods of providing local protection to individuals who must be exposed to high level noise as well as to methods of attenuating noise as it travels between the source and the receiver, e.g., the planting of trees and other sound absorbent structures between highways and residences, noise attenuation standards for both interior and exterior dwelling walls and ceilings, etc. Again, this effort should be supported through both an in-house and outside contract and grant R. & D. effort.

Additionally, the Environmental Protection Agency might consider supporting the training of professionals to work in this area. There has been no mechanism to provide training in applied acoustics, psychoacoustics, and noise control, of the kind needed to train building inspectors, police officers, architects, urban planners, and so on. Most universities appear to consider any kind of applied training inelegant. And yet we obviously need such people.

Finally, the Environmental Protection Agency should, and undoubtedly will, suggest both legislation and regulation. The technical expertise to support such activities must be developed and utilized maximally. Any form of pollution control is expensive, often from a social as well as a monetary viewpoint. Our efforts will not succeed without a comprehensive program designed to support our requests and suggestions that the United States do something about the increase in our environmental noise problem.

Let me conclude with some perspective on the problem. We, as a Nation, are likely to be behind much of the free world in environmental noise control. There are 13 countries, for example, which have—and have had for years—stringent performance requirements for noise insulation between units of multi-family dwellings.

We are told that in Sweden every village has a local public health officer who, if approached by one citizen with a complaint about a sanitary nuisance—odor, noise, and so on—is required by law to carry out a complete investigation. If his investigation indicates the complaint is valid and abatement measures are possible, he is empowered to see that they are employed or to shut down the offending plant.

Also, in Sweden, the National Institute of Public Health apparently plays a major role not only in research but also in setting criteria and standards and in such necessary implementation steps as the training of building inspectors on testing for noise insulation performance in buildings.

In England, we are told, the licensing exam for architects contains a rigorous section on noise control in buildings.

In Switzerland, there is a special enforcement squad of the police who specialize in vehicular noise, who operate without sound level meters but with an instrumented test track available and who, if they find a vehicle which has been purposely modified to make more noise, simply confiscate it on the spot and the owner completes his journey on foot; the owner can get it back after he has had it fixed and tested.

There are several major airports in Europe which maintain noise monitoring systems and use them to control flight paths and limit takeoff gross weights of noise-marginal aircraft. In England, the Institute of Sound and Vibration Research at the University of Southampton, offers an opportunity for interdisciplinary research and study of noise that is, to my knowledge, not duplicated anywhere in the United States.

I feel that I could go on at considerable length, but I knew I had better stop right here.

Thank you very much.

Dr. **Meyer**. Thank you for highlighting the ideas that you have. Dr. Botsford, do you have any questions or comments?

Dr. **Botsford**. I have no questions for the witness.

Dr. **Fidell**. I have none that are of a succinct enough nature to discuss at this point.

Dr. **von Gierke**. One brief question about human design limits. I guess it is clear to most of us that research on the physiological and psychological effects of noise is required, and that we need better correlation between cause and effect of this area.

On the other hand, I think we also know that this research will never give us the design limits. The design limits have to be set on the basis of economic, social, or ethical decisions, and I submit that—as you quoted from other countries, which do much less research in noise—they have such design limits. And I wonder what you propose to arrive at such design limits or goals?

Dr. **Cunitz**. My feeling is that we do need in this country more research emphasis in these particular kinds of areas—the physiological stress, and so on.

The point is that, in a sense, you and I have a feeling that we can say this is too much noise, and it is very simple. We pick the level and say: Okay, that is enough, because it bothers me personally. But I suspect—and I hope you agree with me, or it is unfortunate that you probably will agree with me—that decisionmaking in this country is based as much as possible upon hard facts. If we have got that kind of data we have got something to argue with.

For instance, I am particularly interested—personally interested—in the effects of noise on sleep. It is possible to be awakened by noise. It is possible to be awakened and not remember that you were awakened by noise, and thus have your sleep disturbed. I, for instance, know—my wife reports at least that I talk in my sleep and carry on rational, logical conversations in my sleep. I don't remember them. I suspect we often don't remember being awakened by noisiness—"things that go bump in the night." Furthermore, as I pointed out before, it is possible to go from a deeper stage to a lighter stage of sleep. There was considerable evidence presented along this line at the AAAS meetings in the city of Boston several years back.

The point that I am getting at is that we can do research to find out at what levels are people affected by noise in terms of this particular question, in terms of sleep interference. And we can come up with a design limit that says: Thou shalt not exceed 40 dB—whatever it might be—at night while people are sleeping because it is going to interfere with their sleep.

The corollary, of course, in this particular situation, is the well known effects of sleep interference and sleep deprivation.

Dr. **Fidell**. May I add they are not that well known, that there have been studies done keeping people on deprived schedules 400 days and they show no effects of deprivation?

Dr. **Meyer**. I suspect with O'Hare. The Chairman would venture the view that tomorrow with the series of witnesses we have, we are going to hear quiet a lot of comment on this.

Dr. **Cunitz**. I suspect you will, also.

The point is that continuous sleep deprivation—something in the 80- to 100-hour range—has been shown to produce paranoid psychoses of various and sundry sorts—a rather frightening phenomenon. And that similar phenomenon have been shown when certain levels of sleep are continuously interrupted.

The point is we really don't know how bad it all is. If one can assume that a normal sleep cycle—for instance, addressing to this particular problem—the usual 90-minute repetitive pattern occurs, and you know quite normally without noise interruptions—what happens when this is interrupted? We just don't know. And the plea that I am making is that the Office of Noise Abatement and Control, as has other offices in areas within the Environmental Protection Agency established a research program in-house as well as outside to go ahead and to start looking into some of these kinds of problems, and to provide yourselves with the communition you will need when it is time to go to Congress to get this legislation and regulations passed.

Dr. **Whitcomb**. I would like to comment on the sleep thing, too, that in the absence of knowledge I think we ought to find out.

However, at the present time, your comment that changing EEG levels would lead to irritability the next day wouldn't necessarily be founded. It is a conjecture, and so far nobody has noted that. When you have noise levels that are high enough for behavioral awakenings and have this in an aging population of men and women 75, 80 years of age, then you do get irritability under the awakening condition. But simply light noise levels that change level of EEG may or may not be likely to make somebody irritable.

Dr. **Cunitz**. I thoroughly agree with you that we do not know. I am suspicious, as a scientist who has done some work—certainly not by any means the most eminently—you know, the most important work in this field—I am suspicious of anything that disrupts the noral human physiology.

The point is, I am saying not only do I not know, but I think we ought to find out. And, of course, people who are exposed to noise—there are reports all through the literature of people who are exposed extensively to noise. They suffer irritability. The report around London of increased mental hospital admissions, and so on, all of which may have their problems in terms of being good, but they are certainly indicative that we ought to be looking in these areas.

Dr. **Whitcomb**. I share your concern. Any chronic regular-appearing thing during a person's lifetime could have physiological effects and behavioral consequences, and so on, whether it is routine taking of aspirin or anything else, and we ought to look at it.

One thing I just wanted to comment. You mentioned the need for applied workers rather than basic research people. I think you are going very likely to be seeing more of these people coming to the fore as noise legislation is passed which requires people to do routine audiometry but without necessarily being sophisticated in the area—people who make noise level measurements; people who enforce noise. And the brighter of these people are going to do some pulling together of data and some applied work.

Dr. **CUNITZ.** Of course, I mean, as you know, NASA supported considerable university efforts to develop the kind of technical ability this country has needed for the Apollo program. I don't think that EPA need go into that kind of expenditure on noise. On the other hand, I think some judiciously placed grants to universities that at least are started in this direction might be very useful, you know, if the financing can be available. I am hopeful that the Agency will apply for these kinds of funds so this kind of work can be done.

Dr. **WHITCOMB.** I didn't really mean university training which would end in a B.A. or Master's level, but rather just a short 6-week training period of how to use an audiometer or how to use a sound level meter, and so on, and it may be that we will get a lot of data out of the thousands of people that will be trained this way.

Dr. **CUNITZ.** I am aware of this consequence.

Thank you very much.

Dr. **ELDREDGE.** There is another question—I think it is a little bit to one side of what you were saying, but I sometimes like to turn things around a little bit in order to see what happens, and I have been turning around the following question: Suppose the people who attend, for example, the schools in East Boston, where the airplanes come right over, were to record on a high fidelity tape recorder the sounds for an hour in the morning, and then take this equipment into the airline terminal and turn it on and play it back at the same level it was recorded. And what would happen?

Dr. **CUNITZ.** Well, they would probably get busted. (Laughter)

Dr. **ELDREDGE.** Yes, but why? But why? In other words, this leads to the question which hasn't really, I think, been asked quite, and this is: What right do these students have to go in the airline terminal and make this noise?

But you ask the question the other way: What right do the airlines have to come into the school building and make this noise?

And I don't know whether you would have any reactions to that proposition.

Dr. **CUNITZ.** I personally couldn't have said it better.

Dr. **BOTSFORD.** I would just like to see it tried.

Dr. **MEYER.** Do you have any other comments, Dr. Eldredge?

Dr. **ELDREDGE.** No.

Dr. **MEYER.** Well, I think one of the things that you have said here is that we do need to be conducting research on several levels to deal with some of the, if not unknown, at least partially known, problems. As one of the participants said, he would like to see EPA undertake research projects to get more meaningful correlation of hearing losses in school situations such as were described.

We have got to do more of this, I agree with you, and not just at the sophisticated level. However, as Dr. Whitcomb has pointed out, there is a great need for getting more people who are knowledgeable at a certain level and trying to pull together the data that can be accumulated that way as well.

The training requirement problem is certainly one that we intend to examine at EPA in considerable detail.

Dr. **CUNITZ.** I was aware you were interested in it and I thoroughly concur.

Dr. **MEYER.** Thank you very much.

At this point, then, I would like to ask our last scheduled witness, Mr. Jack Kelley, from the city of Pittsfield, Noise Abatement Activity Committee. Mr. Kelley.

## STATEMENT OF T. JACK KELLEY, COMMISSION MEMBER, CITY OF PITTSFIELD, NOISE CONTROL COMMISSION, PITTSFIELD, MASS.

Mr. **KELLEY.** Dr. Meyer, gentlemen. I want to thank you for the opportunity to speak today. I am a Member of the City of Pittsfield Noise Control Commission.

Now, this Commission was established one year ago by the Mayor in Pittsfield to find out what can be done on a community level as far as regulating the excessive noises that people are exposed to continuously.

After a year of meetings—or perhaps I should say after about 9 months of meetings, we decided that after talking with many, many people with various problems of a specific nature from a specific area of town, that the best thing we could do would be to try to draft a noise control ordinance to be adopted by the City Council. Now, in attempting to come up with this ordinance, what we did was we researched many existing ordinances and tried to find a model that we could use. We looked at many of them—the Chicago ordinance; the Memphis, Tennessee, ordinance; we looked at Atlanta, Georgia, ordinances; we looked at many of them, and we just found that there was no one that we could adapt to Pittsfield in itself.

We finally took a little bit of each one, put them all together, and came up with what we feel the City Council will adopt. Now, we have not presented this ordinance to the City Council as yet. However, the ordinance reads as this:

### UNNECESSARY NOISE PROHIBITED

Section 1. It is found and declared that the making and creation of loud unnecessary or unusual noises within the limits of the city of Pittsfield is a condition which has existed for sometime and the extent and volume of such noises is increasing. The making, creation, or maintenance of such loud, unnecessary, unnatural or unusual noises, which are prolonged, unusual, and unnatural in their time, place, and use effect, and are a detriment to public health, comfort, convenience, safety, welfare, and prosperity of the residents of the city of Pittsfield, and the necessity and the public interest for the provisions and prohibitions hereinafter contained and acted is declared as a matter of legislative determination and public policy. And it is further declared that the provisions and prohibitions hereinafter maintained and enacted are in pursuance of and for the purpose of securing and promoting the public health, comfort, convenience, safety, welfare and prosperity, and the peace and quiet of the city of Pittsfield and its inhabitants.

Now, I am not going to read this ordinance in its entirety, gentlemen. I am going to read just one more section which we consider to be the most important section of this particular ordinance:

"It shall be unlawful for any person to make, continue, or cause to be made, or continue any loud, unnecessary or unusual noise, or any noise which either annoys, disturbs, injures, or endangers the comfort, repose, health, peace, or safety of others within the limits of the city."

Now, the ordinance goes on with some specifications as to types of noises, horns, signaling devices, and so forth; radios, phonographs, and so forth; yelling and shouting, and so forth; animals, birsd, and so forth; exhaust systems; loading and unloading; opening boxes; construction or repairing of buildings, schools, courts, churches, hospitals—noises in these areas; drums; hawkers; peddlers; metal rails, pillars and columns; transportation. There are certain specifications under each one of these categories.

However, the most important thing that I feel I wanted to say is that in this ordinance we did not at any time attempt to use any specific numbers. We had a very good reason for that. After a great deal of deliberation and much thought, it was the concensus of the members of this Commission of whom I am one of five that it would be extremely difficult to enforce an ordinance of this type with numbers in it, especially since there is no State standards or no Federal standard on which to base it.

Any litigation that we might encounter or that the enforcement agency, the police department, might encounter—their hands would be tied. They could be knocked down by any lawyer in any court.

So one of the biggest points that I want to make here is that I think it is imperative that the Environmental Protection Agency, through its office of Noise Abatement and Control, arrive at some type of standards, specifics, upon which a community such as the city of Pittsfield, 60,000 inhabitants, can base a noise control ordinance and get proper and fair enforcement of that ordinance.

Thank you very much.

Dr. MEYER. One of the things that the Congress will indeed charge this agency with is just exactly that. Both the executive branch proposals and those which the members of the legislative branch would submit in other proposals have considered that this is a real problem. We wanted to mention that there is a need for providing technical assistance in the form of model laws, codes, and ordinances.

We are going to, as rapidly as we can, even in advance of the enactment of such legislation, make available to the general public an extensive study on this whole problem of municipal and State law, which we will have completed with our report to Congress. It will be available very shortly. This should be useful to people like yourselves who are charged with their local government to try to deal with the problem.

I will ask the panel if they have any comments. Dr. Eldredge?

Dr. **ELDREDGE**. No.

Dr. **WHITCOMB**. You are absolutely right that this is probably more enforceable than a law with numbers in it. We had heard testimony before that a similar ordinance such as yours had been effectively used. But the language of your ordinance, I guess, is what bothers me.

I would be arrested for cutting my grass with a power mower, and I think the police chief might end up with more people in jail than out.

Mr. **KELLEY**. That is very true, doctor, and I think it is written that way specifically. We are going to rely a great deal on enforcement to the members of the police department in the city of Pittsfield, and we are going to rely on good common sense.

Dr. **WHITCOMB**. Okay. The problem, then, is, as a resident in Pittsfield, unless I know what is in the minds of the police officers, I am not going to know what I can and can't do.

Now, are they going to give examples of what they will consider acceptable?

Mr. **KELLEY**. I don't believe so.

Now, I want to go back to the section of the ordinance here, doctor, I think, that you might be referring to: "It shall be unlawful for any person to make, continue, or cause to be made or continued any loud, unnecessary, or unusual noise."

Now, the terminology "unusual noise" I think would apply if you wanted to cut the grass; with the exception, however, if you cut the grass at midnight nextdoor to the fellow that has got to get up at 4 o'clock in the morning.

Dr. **WHITCOMB**. No, so far the language is fine. It is when you elaborate later and talk about noise that is annoying and there are—

Mr. **KELLEY**. ". . . or unusual noise, or any noise which either annoys, disturbs, injures, or endangers the comfort. . ."

Dr. **WHITCOMB**. You will find people are annoyed just by the timber of another person's voice—literally.

Mr. **KELLEY**. This is very true. Loudness is subjective to each individual.

The only thing that I can say there: Here again, it is a matter of common sense. We are going to try to get this ordinance passed the way it reads, as tough as it may seem.

Dr. **MEYER**: If I could interject one thought. The National Institute of Municipal Law Officers has, of course, studied this problem and looked at both ordinances which were based on subjective reactions, such as this one, and those which have finite decibel limits, and there are advantages and disadvantages in both.

What really happens is that the court, in enforcement of one stated as that one is stated, by its initial decisions sets the pattern for what is considered to be reasonable and unreasonable. In effect, the level of annoyance is then set by the judge in determining whether or not a reasonable person under reasonable circumstances would be so affected. This phenomenon has been studied.

Mr. **KELLEY**. That bit of information right there was worth my trip coming down here.

Dr. **MEYER.** What you are saying, in effect, is that each case is more or less going to be judged on its merits but the court will set the pattern. Once those precedents in municipal court become established, rules emerge.

Mr. **KELLEY.** I thank you for that information.

Dr. **VON GIERKE.** I think in this respect legally noise is treated as public nuisance which is more or less covered in most States as part of their present city ordinances and regulations.

I might say in the town I grew up more than half a century ago, Amordair, there was a strict enforcement of such public nuisance noise annoyances. And I mean certain activities in apartment houses and also the city, like blowing your horn or cleaning your rugs outdoors were restricted to certain times of the day, and this was in the city code and was strictly enforced.

Mr. **KELLEY.** Well, we have found that in Pittsfield there was no specific ordinance to cover noise. Now, noise was covered in other ordinances of different natures, and one of the things that we felt was that a specific ordinance in the city laws to cover noise and its abatement and control was what we needed to give the police department a little bit of teeth to enforce something. It was too ambiguous the other way.

Dr. **FIDELL.** I have a few quick comments, since you pointed out the advantages of not having dB numbers in there, let me quickly point out some of the disadvantages.

For one thing, it can be construed as a deterrent of free speech and unconstitutional if you do not permit public address systems, and so forth. If you base it implicitly on ambient noise levels, the ambient noise levels in a community can escalate a few dB at a time. If a factory moves in down the street, he doesn't make much noise, but the next factory does, and with a few more you are up a few dB, and before long it is no longer "unnatural or unusual" to have high noise levels.

There is also problems with vagueness and being comprehensible to citizens and it also places considerable discretion in police power which can be construed as harassment if inappropriately applied and the whole ordinance struck down.

So I think the city of Pittsfield is commendable in its interest in the ordinance but should be aware of the dangers of indiscriminate enforcement.

Mr. **KELLEY.** Thank you.

Dr. **MEYER.** Well, I made a quick glance at the National Institute of Municipal Law Officials' suggestions. Most of the precautions that they suggest with regard to unnecessary noise type standards are reflected in your approach. Apparently you have given careful consideration to that statement.

Mr. **KELLEY.** Yes.

Dr. **MEYER.** They point out the problems of both the unnecessary type noise ordinance and the decibel ordinance.

Mr. **KELLEY.** One of the things that we have in mind is that to get an ordinance adopted and then amended as specifics become available to amend it, but we feel that it is necessary to do something quickly and as quickly as possible.

Dr. **MEYER.** Well, it sounds like you are making a very forward step and we appreciate your bringing it to our attention, sir.

Mr. **Kelley**. Thank you.

Dr. **Meyer**. There being no further business for this session of hearing, it is recessed until tomorrow morning at 9:00 o'clock, at which time a series of scientific and professional witnesses will be heard.

Thank you for your presence. We stand recessed as said.

(Whereupon, the hearing recessed at 5:10 p.m.)

# ENVIRONMENTAL PROTECTION AGENCY

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## PUBLIC HEARING ON PHYSIOLOGICAL AND PSYCHOLOGICAL EFFECTS OF NOISE

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### FRIDAY, OCTOBER 29, 1971

The hearing was reconvened persuant to recess at 9:15 a.m., Dr. Alvin F. Meyer, Jr., Director, Office of Noise Abatement and Control, Environmental Protection Agency, presiding as chairman.

*PANEL:*

- Dr. James Botsford, Sr. Noise Control Engineer, Bethlehem Steel, Bethlehem, Pa.
- Dr. Donald Eldredge, Central Institute for the Deaf, St. Louis, Mo.
- Dr. Sanford Fidell, Bolt Beranek and Newman, Cambridge, Mass.
- Dr. Henning von Gierke, Aerospace Medical Laboratory, Wright-Patterson Air Force Base, Dayton, Ohio
- Dr. Milton Whitcomb, National Academy of Sciences, Washington, D.C.

## PROCEEDINGS

Dr. **MEYER**. Ladies and gentlemen, I hereby call the third sitting of the Environmental Protection Agency's public hearing on noise abatement and control to order.

Let me, again, for the benefit of those who were not here yesterday, briefly explain the purpose of the hearing and the method by which it is conducted. The purpose of this hearing is to obtain information for use by the Environmental Protection Agency in submitting its report to Congress called for by title IV of Public Law 91-604, and also to provide information which the Environmental Protection Agency may utilize in implementing any legislation which is passed by the Congress. There are now pending in the Congress several acts relating to noise control.

I should now like to introduce the panel. I am Dr. Alvin Meyer, Director of the Office of Noise Abatement and Control, acting for the Administrator of the Environmental Protection Agency, Mr. William D. Ruckelshaus. I am assisted in this effort by Dr. James Botsford of the Bethlehem Steel Corporation; Dr. Donald Eldredge, Central Institute of the Deaf, Washington University, St. Louis; Dr. Sanford Fidell of the firm of Bolt, Beranek and Newman; Dr. Henning von Gierke of the Aerospace Medical Research Laboratories, Wright-Patterson Air Force Base; Dr. Milton Whitcomb, National Research Council, National Academy of Sciences, Washington, D.C.

Today we are receiving information from a variety of professional specialists, who are concerned with the problems of noise and its effects on man. This is an important hearing because there are some differences of opinion in the scientific community about certain aspects of the noise problem, and just as it is valuable for us to hear from different segments of the public, it is also valuable to get into the record the many varying views regarding the significance of noise as an environmental problem.

At this point, then, I should like to ask if Dr. John Dougherty of the School of Public Health of Harvard is here yet. If he isn't—since he doesn't seem to have arrived yet—if Dr. Carr is here.

All right. Dr. Sackler and Dr. Weltman. Dr. Weltman is here. We will start off with Dr. Weltman and proceed back to Drs. Daugherty and Carr when they arrive.

Also I would like to request, while Dr. Weltman is coming up, that if any witnesses who prepared statements yesterday and did not deliver them to the panel or to the court reporter, will they do so today. If the witness has a prepared statement, please deliver it to the court reporter and to my representative, either Mr. Hardesty or Mrs. Seidman.

Good morning, doctor.

## STATEMENT OF A. STANLEY WELTMAN, Ph.D., SENIOR RESEARCH INVESTIGATOR, LABORATORIES FOR THERAPEUTIC RESEARCH, RESEARCH INSTITUTE OF BROOKLYN COLLEGE OF PHARMACY, LONG ISLAND UNIVERSITY, BROOKLYN, N.Y.

Dr. WELTMAN. Good morning, gentlemen. I wish to thank the Environmental Protection Agency for inviting us to present our testimony today at the Noise Abatement and Control Hearings.

I am Dr. A. Stanley Weltman, Senior Research Investigator of the Laboratories for Therapeutic Research at the Research Institute of Brooklyn College of Pharmacy, Long Island University. Dr. Arthur M. Sackler, Director of the Laboratories for Therapeutic Research and Chairman of the International Task Force on World Health Manpower for the World Health Organization regrets he cannot attend this session. Unfortunately he was called away at the last minute. Now for our testimony.

Considerable controversy and contradictions have existed concerning the deleterious nature of environmental and industrial noises. Various investigators claim noise leads to ear damage and hearing loss (1, 2, 3, 4, 5), annoyance (6) disturbs work performance, rest and sleep (2) and may be deleterious to health, particularly for individuals with emotional disturbances and so-called tension diseases (7). Others have studied effects on heart function and performance (8) and have reported additional harmful and pathological effects in the body of man and animals (9, 10, 11, 12). In man, exposure to intense industrial noises and airplane sounds have been reported to cause fatigue, irritability, insomnia, nausea, headaches and loss of libido (13). In contrast, it has been reported that auditory stimuli cause no substantial effects except for ear damage (14). In part, much of the variabilities and inconsistencies of the various findings of man and animals can be ascribed to differences in the intensities and frequencies of the sound stress or sound mix, the duration of the stress, combination of noise and other environmental variables, in addition to species and sex differences.

In reality, behavioral and physiological aspects of noise should be considered in light of its effects on not only the so-called normal individual but also the abnormal individual as well. In man, the so-called startle or acoustico-motor epilepsy can be triggered by the sound of loud noises and in some patients seizures can be induced by particular types of music (15). In general, the mass of literature have been concerned with effects of industrial noise on behavior and physiological function of allegedly normal subjects. Other utilizations of noise stress have been attempts to correlate the relationship and behavioral and physiological differences of audiogenic-seizure susceptibility in animals to epilepsy in man.

In studies of behavioral and endocrine differences in audiogenic-seizure susceptible female rats (16, 17, 18), Sackler and Weltman (16) have noted increased timidity in seizure-susceptible rats as measured by the time required to leave a home cage and reach food, as well as significant increases in urine volume and fecal elimination. Endocrine findings by the laboratory (17) have indicated increased adrenocortical output in the noise-susceptible rats as determined by significant adrenal and pituitary weight increases, significant thymic involution and heightened urinary 17-ketosteroid output. Hyperthyroidism was not apparent in the susceptible rats but rather the reverse was noted. Oxygen consumption rates were markedly lower as well as relatively similar decreases in the thyroid weights. It is of interest that grading and scoring the severity of seizure-susceptibility according to the frequency of wild-running seizures and convulsions (18) indicated highest adrenocortical activity in the most noise-susceptible rats as well as the lowest rate of $0_2$ consumption. Urine volume and fecal pellet excretion were similarly significantly highest in the most susceptible group furnishing evidence of alterations in excretory reflexes and food metabolism of noise-susceptible versus resistant female rats. Similarly, adrenal ascorbic acid levels were significantly higher and $0_2$ consumption rates markedly lower in the most susceptible group of audiogenic-seizure susceptible rats.

The criteria chosen for this category were the occurrence of wild-running seizures and convulsions at all three trials of auditory stress stimuli having a loudness of 115-120 dB. It should be noted that Anthony (1955) reported that the eosinopenic response to several successive bursts of noise stimuli (110 dB) was more marked in audiogenic-seizure susceptible versus seizure-resistant mice. (40)

In conventional studies of noise stress in the early 1950's Miline et al. observing animals exposed to industrial factory noises reported hyperplasia and pathological changes in the adrenals (9) as well as degenerative changes in the thyroids (10) and heart (12). In the testes of rats, Miline et al. (11) reported oligospermia, atypical spermatogenesis and interstitial hyperplasia. Bugard (14), conversely, reported no pathological alterations in the adrenals or other organs of animals (rabbits, guinea pigs and dogs) exposed to intense stress of 130 dB. Anthony and Ackerman (19) reported that mice exposed to moderately intense noises of 110 dB displayed moderate adrenocortical activity as deduced from eosinopenia and adrenal hypertrophy. In early studies, the absence of thymic-lymphatic involution caused them to prematurely rule out noise as a harmful variable. They reported that the exposure of male guinea pigs (20) to intense, low frequency noise (139-144, dB, 300-4,800 c.p.s.) while increasing adrenal activity did not apparently alter sexual performance of the males or cause reproductive and/or other pathologies. It is of interest that in later work with high intensity and high frequency noises (135 dB, 2-40 kc/sec.) and repeated exposures, Anthony et al. (21), did observe pathology in adrenals and other organs but none with low frequency noises. Hale (22) found white noise increased adrenocortical activity and that exposure of male rats at infancy increased the emotionality of the rats at maturity. Female rats were less responsive and did not show increased adrenocortical activity, increased emotionality or evidence of interference in reproductive function, conception, gestation and parturition.

In studies conducted by Sackler and Weltman, our findings with white and pure noises involving groups of normal female (23, 24, 25) and male rats (25, 26) exposed for short periods of 1-5 minutes to noise levels ranging respectively from 95 to 120 dB, indicated that depending upon intensity and duration of stress, decreases were noted in body weights and food consumption. The findings also revealed increased adrenal activity, thymic involution and reduced gonadal activity in the test animals.

Groups of female rats were exposed singly to one minute auditory stress trials produced by an electric buzzer having a loudness of 110 dB and a mean intensity of 375-500 c.p.s. for two weeks (11 trials). In related studies other groups of mature female rats (five per cage) were exposed to five minute periods of similar auditory stress for three weeks (15 trials). In general, stressed females weighed less than control rats and had lower food consumption. Increases were observed in the adrenal weights and the ovarian and uterine weights were lower. Histological examination of the ovaries showed fewer numbers of mature ova in the noise-exposed rats and histological studies of the pituitary also suggested lowered gonadotrophin and gonadal activity in the femael test rats as indicated by lower ovarian and uterine weights.

In experiments with mature male rats (25, 26) using electric buzzers (90–95 dB; 375–500 c.p.s.), alarm bell (115–120 dB: 420–600 c.p.s.), and pure tone sounds (115 dB; 1,000 c.p.s.), despite the type of auditory stimulus applied in general, the following results were obtained:

1. Decreases in food consumption and some evidence of decreased water consumption.
2. Increases in adrenal and pituitary weights accompanied by thymus weight involution.
3. Reductions in the seminal vesicle weights indicative of reduced gonadal function.

Although no abnormalities were noted in the processes of spermatogenesis or spermiogenesis, decreases were observed in the number of interstitial cells. Thus, in the female and male studies our findings with mixed and pure noises for even relatively short periods of 1–5 minutes at levels ranging from 95–120 dB showed decreased food consumption, increased adrenal activity and reduced gonadal function.

Behavioral response patterns (25) noted prior to, during and after auditory stimulation over a three-week period indicated a broad spectrum of varied changes undifferentiated by the type of stimulus. Locomotor and exploratory activity were reduced in both male and female stressed rats.

A. The noise stimulus produced a rapid grouping of most of the animals who would assume a huddled or frozen position in a corner of the cage. These postures were generally maintained with little change or interruption throughout the five minute noise exposure period. Some rats revealed a sporadic tendency to leave and return to the huddled formation while still others maintained constant activity, continuously and randomly exploring the cage. The gamut of individual responses ranged from complete inactivity to continuous activity during the noise-stress period.

B. Upon cessation of the auditory stimuli, variations in behavioral response patterns were likewise demonstrated. Most of the grouped male and female rats maintained their frozen and immobile status up to and even exceeding the five minute post-noise period. Other animals gradually recovered locomotor activity at varying intervals. In general, the rats which tended to leave the huddle during the exposure period were among the first to recover and emerge from the frozen position or huddle in the post-stress period. Rats which had maintained continuous activity during the noise period similarly displayed continuous activity during the post-noise period. In addition to random and circular exploratory activities, marked increases were observed in the grooming and washing activities of the male and female rats. As the studies continued, a specific pattern of activity could usually be associated with specific rats. Those who exhibited a withdrawal pattern by retreating to various corners, remaining in a comparatively quiescent state prior to initiation of the stimuli, were usually the the earliest to freeze, huddle and remain inactive during and after the application of the noise stimuli. The other extreme was presented by rats which displayed comparatively heightened locomotor activity prior to the noise and subsequent to its application. Subjectively, these rats appeared somewhat more excitable than the corresponding control rats.

Others such as Henkins and Knigge (27) exposing rats to intense low frequency noises (130-135 dB, 200-220 c.p.s.) have also demonstrated a pattern of increased adrenocortical activity as evidenced by increased corticosterone output following auditory stress. Johns (28), similarly, reported that the marked leukopenia in male rats exposed to 112 dB primarily involved lymphocytes. Hrubes and Benes (29) using repeated noise stress observed increased urinary catecholamine excretion in rats. Ogle and Lockett (30) using high frequency stress (100 dB, 20 kc/sec.) likewise noted increased urinary adrenaline output in the test male rats but none in animals exposed to low frequency noises of 150 c/sec.

It is of interest that Zondek and Tamari (31) reported persistent estrus, enlarged ovaries and uteri in mature rats and rabbits exposed to repeated intermittent bursts of sound (110 dB) totalling approximately 144 minutes/day over a period of weeks. They reported a stimulating effect on adrenal function and pituitary gonadotropic release. Ovaries and uteri were markedly enlarged. However, unlike Hale (22), Zondek and Tamari (31) did observe greatly diminished fertility in the stressed male and female rats and decreases in litter sizes. Hagino (32), similarly, reported persistent estrus and lower sexual receptivity in female rats subjected to prolonged auditory stress.

A possible hypothesis explaining the diverse effects of auditory stress may be that noise exerts a diphasic effect on reproductive function. Depending on strength, daily but short exposures to audiogenic stress may have an inhibitory effect on gonadotropic release and gonadal organs whereas daily, intermittent and/or prolonged exposure may ultimately stimulate gonadotropic release as reported by the latter investigators.

Other investigators have also observed that noise stress combined with other variables applied during the pregnancy can effect embryological and offspring development. Geber (33) using intermittent audio-visual stress given for a period of 6 minutes/hour/day up to the 16th day of pregnancy observed cases of complete resorption of litters, reduced litter sizes and developmental abnormalities in embryos and removed at the 16th-20th days of pregnancy. Geber (34) also exposing animals to maternal stress produced by noises of moderate intensity (range 73/93 dB; average 83 dB) observed smaller litter weights in rats and rabbits and marked increases in the number of fetuses exhiting subnormal body weights. Peters (35) reported cleft palates in offspring of mice exposed to noise levels of 103 dB and hunger stress. Behaviorally, Morra (36) reported that exposure of rats during the 10th-17th days of pregnancy caused significant decreases in the locomotor and body activity of the offspring at 30 and 45 days of age.

Recently, Ward et al. (37) exposing pregnant mice to the intermittent noise stress of a motorcycle horn at sound levels of

82–85 dB (320–580 c.p.s.) with the noise applied for approximately 60–75 percent of each hour for 2 days during pregnancy, reported resorption of fetuses, reductions in fetal weights as well as various cranial and limb defects in developing embryos.

It is of interest that studies of human fetal responses to acoustic stimuli transmitted through the maternal abdominal walls revealed increased fetal heart and pulse rates as noted by Tanaka and Arayama (39). Similarly, alterations have been reported in the encephalogram of stressed fetal guinea pigs when mothers were exposed to sound stimuli of 132 decibels as reported by Scibetta and Rosen (38).

In conclusion, from the various reports of other investigators as well as our laboratory, environmental and industrial noise represents a biological hazard which must be considered in man's everyday activity. It represents a danger to all stages in life from the unborn to the aged.

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Dr. **MEYER**. Thank you, sir, I will now ask the panel, starting with Dr. Eldredge, if they have any questions or comments.

Dr. **ELDREDGE**. You mentioned seizure-susceptible rats. Do you consider the seizure-susceptible rats to represent the normal population or are they some way abnormal?

Dr. **WELTMAN**. No, the seizure-represented rats are abnormal population. As a matter of fact, I should add that in scrutinizing the data of other investigators where they used applied noise stress too infrequently they have included populations of audiogenic seizure-susceptible animals in their experimental results which tend to confuse the data that they publish.

Dr. **ELDREDGE**. And I had another question about the problem of the rats who did not freeze in a huddle in your experiments.

Did you have evidence that, as a matter of fact, they could hear?

Dr. **WELTMAN**. Oh, yes, all of the rats—well, we could see from their movements of their ears that they were hearing, and I should make a statement that unfortunately our populations were not large enough, but I find it quite interesting to study particularly the behavioral response patterns of the rats which are receptive versus rats which freeze, and to attempt to correlate them with their endocrine function, because I believe they may show interesting connotations.

Dr. **ELDREDGE**. And one of the things that sort of eluded me, if it was there, is the question of the following distinction to how much of what you are observing do you attribute to the fact that noise might be a stress and these are various stress responses, and how much do you attribute to something that is peculiar to noise apart and different from other stresses?

Dr. **WELTMAN**. Well, to a great degree, some of the effects of noise are attributed to—can be attributed to a psychological factor. It is a strange and intense noise which, although we cannot have an indication that the rats are suffering pain as human beings do we read into it that perhaps they have pain. So, much of the stress which they are subjected to is of a psychological nature and emotional nature. This is our impression of the effect of noise stress.

Similarly, there is the effect that the emotional stress, the noise stress, the fright which is created in the animal stimulates the adrenocortical activity, which in turn has its effects on other tissues and organs of the body.

Dr. **ELDREDGE**. So that the principal thing, then, here is associated with the fact that this is not necessarily painful but it might be frightening and it leads to various reactions that follow such a fear.

Dr. **Weltman.** Certainly with the lower noise stresses, which we use, of 95 to 95 decibels, I would not call that a painful situation, judging from the human symptomology, but I would consider the fact that this is an emotional stress which stimulates the adrenocortical system and probably inhibits the thyroid activity affecting in turn food consumption, body weights and other gonadal performance as well. This would depend necessarily on the intensity, the strength and the prolongation of these experiences.

Dr. **Eldredge.** Then, there is the very obvious question that goes along here and that is having seen these various responses in rats, have you had the opportunity to make similar observations at all in people with respect to such things as you could observe—for example, eating habits or things like that?

Dr. **Weltman.** Well, unfortunately, our researchers have not entailed studies with humans, but from the literature available by other scientific investigators we have had indications that noise creates anxiety in human beings which will affect their appetite, their well being and performance.

Dr. **Eldredge.** Thank you.

Dr. **Whitcomb.** I really don't have a question as much as a statement. After listening to this testimony and considering it, it seems, first of all, unfortunate that most of the data are on rodents which are not really a uniquely good animal; and, secondly, that most of us are interested in the relevance to us as human beings.

It would be nice to encourage the funding of perhaps primate research with scaled exposures running from a rather quiet exposure, which could be a control group, on up through 70 dB, 80, and then approaching 130, to find out just where it is that pathology does start, because I think we are all concerned with what does this mean to me more than what happens to a rat.

Granted the initial research is needed to find out if there is a problem, but now I think is the time to undo some purse strings perhaps and look at primates.

Dr. **Weltman.** Well, basically I agree with you in that much more research is needed with humans, but unfortunately or fortunately, as the case may be, studies have to be done with the basic animal such as the rats, rodents, and monkeys in order to apply them to man.

Dr. **Whitcomb.** By primates I didn't mean just me. (Laughter)

Dr. **Meyer.** I am sure we will have some comments about that later. But now I will continue with Dr. von Gierke and my colleagues on the right.

Dr. **von Gierke.** I have some comments in the same direction as the ones posed before, primarily how to interpret these interesting experiments—this goes back to their interpretation to the human species—and one question is: How does a relative level of loudness or hearing acuity in the animal compare to our human sensation? And I think there are indications that under 20 decibels to certain animals is louder and more noise than under 20 decibels to humans. We know this from the damage to the cochlea and from the pain threshold of various animals. I wonder what your comment on this is.

Dr. **WELTMAN**. It is my impression that rodents can hear higher sounds. They can hear higher frequencies than man can. But as to the exact frequencies, I am not quite certain.

But I do know this: that in certain cases, certainly with the seizure-susceptible animals, one sees that these abnormal type animals are much more sensitive because they will go into violent running attacks and go into convulsions whereas it is very rare that you see humans respond, although cases have been cited in that case.

Dr. **VON GIERKE**. My question or comment was not so much with respect to the change in frequency sensitivity but—

Dr. **WELTMAN**. With the loudness.

Dr. **VON GIERKE** (continuing). With loudness and level where we know that the pain threshold and the level of damage to the inner ear is lower in some animals than it is in humans.

Dr. **WELTMAN**. Well, I understand that studies have been done exposing rodents and rats to loud decibel noises and they have studied the effects on damage to the cochlea as well. As to those specific references at this moment I could not cite them.

Dr. **VON GIERKE**. Now, the second question is concerned with what was touched on before already, that the main response you got from the animals is probably a psychological response and a fear response. Now, we are all familiar in industrial and military situations that at the first exposure to an unknown sound, every human shows a fear reaction. That is somehow an inborn reaction, and it is hard to overcome. But after a relatively short time period and exposure experiences you adapt to it and your reaction changes completely.

Now, the way I take it for most of the experiments we heard from you this morning—and most of the experiments I know from the literature—are very short-term experiments and are not really experiments where animals have more or less been raised in this noisy environment.

I think, for example, in your studies of pregnant animals, they were not exposed before pregnancy to any noise stimuli but only during pregnancy suddenly they were blasted with loud sound stimuli which were unknown to them and they really did not have time to adapt to them.

Is this correct?

Dr. **WELTMAN**. Well, in one of these studies which I have reported, they exposed them to—well, almost to the sixteenth day of pregnancy. Other people have exposed them, say, for 2 days to observe effects.

There seems, in general—I should say there is some contradiction in the literature primarily due to the intensity of the noises. But the general thrust of the various publications would indicate that auditory noise and stress does affect the pregnancy, does create malformations and abnormalities in the young, does decrease litter size and litter weights of the animals.

Now, this I think could be applicable—should be considered in the light of its possible effect on the human beings who can be subjected to prolonged stress.

I should cite that with reference—to clarify an issue further—that I did not mean to imply that the effect of the noise stress was purely emotional because, as I indicated from the behavioral reaction of many of the rats, many of the rats appeared almost unconcerned, yet they also moved about frequently and actively, yet they were showing enlargements of the adrenals and decreased weights in the thymus which are indicative of adrenocortical weight increases.

Dr. **von Gierke**. What were the longest exposure times?

Dr. **Weltman**. The longest which we haven't used were 5-minute periods over 3-week periods, but others, I should say, have used intermittent auditory stress for 20 minutes on and 10 minutes off or 20 minutes on and 20 minutes off, and they have done these experiments for weeks and months showing effects of noise on the endocrine system, namely, increased adrenocortical activity and perhaps decreased thyroid activity, and gonadal impairment as well.

Dr. **von Gierke**. Yes, but most of the studies on the reproductive system have been done with pretty acute exposures.

Dr. **Weltman**. No, no, because this—

Dr. **von Gierke**. I mean—

Dr. **Weltman**. Well, in most cases, yes. But I should cite an interesting series of papers by Geber, where they used relatively low decibels of 73 to 93 decibels, which would seemingly be of relatively not the high intensity and painful intensity that 120 decibels have and yet they observed effects on the offspring and endocrine activity.

Dr. **von Gierke**. In any of these studies, were the animals raised in the noise environment prior to becoming pregnant?

Dr. **Weltman**. I don't recall—I know that Hale, in a rather extensive publication, has done repeated studies of long durations where I believe he exposed mothers and it was his claim that there was no effect on reproduction. I know he did an extremely long, prolonged series of studies, but he did claim that there were some effects on the emotionality of the offspring, in the case of one of the sexes, whereas in other sexes there was no effect.

Dr. **von Gierke**. I just wonder if you would agree on this general philosophy that more work should be done on this longer chronic exposure, where you really get the effect of environmental exposure and not the effect of sudden fear and stress responses.

Dr. **Weltman**. This I heartfeltly concur with you, and, in fact, we are planning to go back into that research and use studies with that in mind.

Dr. **von Gierke**. Thank you.

Dr. **Weltman**. Thank you.

Dr. **Fidell**. I found Dr. Weltman's comments enlightening. I have some extreme reservations and some difficulties in interpreting them, and I guess I would like Dr. Weltman's comments on my reactions to his papers, which I hope are not construed as personal criticism but rather as a statement of the state of the art and this sort of research.

I think a lot of this sort of research illustrates the dangers of measurement in the absence of any theory. Since it is not known what variables are worthy of study, any salient variable that is easy to measure is measured, and when the research is complete there is no systematic way of integrating the findings into the mainstream of scientific thinking. One has no knowledge of what is important, what is trivial, what is crucial, what is irrelevant, what controls are useful, what controls are futile.

There is a further difficulty in that adequate control of the acoustic signals employed is frequently missing and that vitiates many of the findings in my mind. It is unfortunate that competence in either physiology or acoustics implies nothing about competence in the complementary fields. Thus we find many studies undertaken by acousticians who employ things like eosinophil counts having no knowledge that if they miss one or two of them they could change the percentages by 10 to 20 percent. And, on the other hand, there are studies undertaken by members of the physiological community in which they speak of the controls which they do not have.

For example, they are unable to specify what the true levels of the signals are that were presented to their animals; they specify them inadequately so that the experiments are not replicable elsewhere; and one could go on and on. So when one has concluded with many of these sorts of studies one is left with a recitation of facts which are of dubious accuracy and a sort of undigested collection of experiments whose implications are difficult to define.

I was wondering if Dr. Weltman also shared that view of the research in this field.

Dr. **WELTMAN**. I agree with many of your comments. That is why I wish to prepare a careful assay of the general field in the topic that we are dealing with, and I wish to present adverse as well as statements which show that noise do have a harmful effect.

Dr. **FIDELL**. Yes, I have —

Dr. **WELTMAN**. May I continue?

Dr. **FIDELL**. Sure.

Dr. **WELTMAN**. With regard to your statements concerning the fact that many individuals, when they conduct the research, don't have the proper standards and standbays, I concur with you. But in the studies which we did, we made careful attempts to record and determine the exact cycles and frequencies and do a spectrum analysis of the general noise which we were producing, so that these—

Dr. **FIDELL**. I have no quibble—

Dr. **WELTMAN** (continuing). Were analyzed so that we could possibly interpret it so that in the event we wished to duplicate it we could always duplicate that type of investigation.

I should say that, as indicated earlier, unfortunately, not all of the information that we find from rodents can be applicable to men. But the basis and thrust of all scientific investigations has been to use the rodents as a tool so that they could apply that to the problem in man.

Now, certainly from other investigators who will be speaking, I presume, today in the scientific area, I think that we will be able to see that there will be evidence in human research as well which will concur with the findings that we have recorded in the rodents.

Dr. **FIDELL**. Well, I have no doubts in my mind on an a priori basis that the findings you report are the potential outcomes of exposures to noise. I think it is not even an issue really how applicable the animal research is to human research. My basic difficulties are in understanding how all of this information is to be integrated in any sensible framework which I find totally lacking. There is no basic theory that says noise of this level and noise of this level will have precisely these effects. There are no predictions, assumptions; one cannot identify what is going on in the experiment. Different people may assume different things for no apparent reasons.

Dr. **WELTMAN**. Well, this I find I can agree with because a careful study has to be done with chronic, as Dr. von Gierke indicated, where chronic long-range studies are being done with definite loud ranges, and apply them to the animals in particular or primates, very varied animals to observe the effects of chronic prolonged studies of different loudnesses and see how these variations can affect the animals.

Dr. **FIDELL**. Let me take one final cut at trying to make clear the thrust of my comments. I am saying: Forget more research, we need more theory. It's time to think, not to do more experiments.

Dr. **MEYER**. Dr. Botsford.

Dr. **BOTSFORD**. I have no questions. Are there copies of Dr. Weltman's statement for the panel?

Dr. **WELTMAN**. Yes, I am sorry. I—

Dr. **MEYER**. Yes, there will be.

Dr. **WELTMAN**. They are available. I gave them to the—

Dr. **MEYER**. They are being Xeroxed right now.

Dr. **WELTMAN**. You should have been handed them.

Mr. **MEYER**. The Chair would make a couple of comments and ask a couple of questions, also.

I am reminded, listening to this discussion, of the view that a very learned and eminent toxicologist, Robert Kehoe, often has said that although some men may act like mice or rats, mice and rats aren't men and that one must view the results of such experiments with great caution.

Similarly though I think the point made here is an important one which the panel and all of us reviewing this testimony must keep in mind. That is, that experiments with lower animals certainly provide guideposts for us as to where to go with our research on higher animals, including man. I know that later on today we are going to hear some testimony from Dr. Grenell and others about primates and primate experiments, so I think this does set the stage very well.

Against that background though I did have several technical questions. The first one is: You used the phrase, as all of us do, the "mensuration value decibel." Does this refer to the basis 0.0002 dynes per square centimeter or newtons or is it measured on the A-scale in this experiment?

Dr. **WELTMAN**. Well, these, I believe, is the 0.0002 dynes per—

as you stated—but the instrument that we used to measure it was the general radio sound level meter.

Dr. MEYER. Then, the next question deals with the control animals. The control animals were given the same degree of handling by handlers and allowed the same degree of movement in the cage, and so on, as the test animals. Is that so?

Dr. WELTMAN. That is correct, Dr. Meyer. In all cases, animals which were exposed to noise stress were transported to a separate room where the noise—the other animals in the general laboratory area could not hear the noise. They were placed and exposed to the noise stress. Now, control animals were similarly carried and placed in the reverberation chamber so that they could be exposed to the noise—not exposed to noise, I am sorry—but so they could receive the equal amount of handling.

Dr. MEYER. Yes, sir. Fine. Well, thank you very much for a very stimulating introduction to the day's activities.

Dr. WELTMAN. Thank you.

Dr. MEYER. At this point, then, I should like to ask Dr. Jerome Carr, who is Environmental Specialist with the Lowell Technological Institute Research Foundation, if he would come forward and give his paper.

While they are putting up the projector we will take about a 5-minute stretch.

(Short recess.)

## STATEMENT OF JEROME B. CARR, Ph.D., ENVIRONMENTAL SPECIALIST, LOWELL TECHNOLOGICAL INSTITUTE RESEARCH FOUNDATION, LOWELL, MASS.

Dr. CARR. The theme of this meeting, of course, is the psychological and physiological effects of noise pollution, and my comments will be directed towards the physiological and psychological effects of the sonic boom and I will also make some comments on the economic implications of the sonic boom.

In case I run out of time, which I hope I won't, the conclusions of my testimony are that the proposed overland flight of the supersonic transport is totally unacceptable on physiological and psychological and economic grounds. The ONAC should be directing a substantial effort towards protecting the public from the overland flights of the SST and should the SST be approved for overland flight, a substantial research program should be designed to begin as soon as SST flights begin.

First, we must establish that we are not talking about a dead issue. To do this, all I have to do is give you a quote prepared or made by John H. Shaffer, who is head of the FAA while he was at the Paris Air Show in June of 1971. Mr. Shaffer said that "The supersonic plane is an absolute necessity." Now, when you have the head of a Federal agency saying that a supersonic aircraft is an absolute necessity, you can be pretty sure that the aircraft industry is going to make an effort to bring this to be over the United States.

The first slide that I would like to show you is a slide showing the distribution of sonic boom overpressure values for an SST flight. (See Figure 1 of Dr. Carr's paper printed after this testimony.)

The important thing to note here is that most of the research papers that you will find talk about the SST flying and producing a nominal or average value of an over-pressure. Our problem is that the atmosphere is a variable propagation medium. The nature of the acoustic wave, the N-wave, is variable, and the nature of the topography giving you different kinds of reflection is also variable, and this produces a variation in sonic boom overpressure level above the nominal or average value.

The important thing to realize is that no matter how low they design this average or nominal value there will always be some high overpressure waves somewhere along any individual flight path, and these overpressure values will be capable of producing physical damage—that is, break a window, crack a foundation, knock a piece of knickknack off a wall, something of this nature.

So this is one thing that the FAA talked about. They say this is perfectly safe. What they forget to tell you is that we have this distribution curve and that the distribution curve does, in fact, produce values that will always produce physical damage.

Now, there is another thing that the FAA tends to play down, and that is the occurrence of what is called superbooms. Superbooms are sonic booms that produce an overpressure value about 4 times or up to 4 times as large as the nominal value. So, in other words, whenever a supersonic plane maneuvers or turns or changes altitude—does anything like this—it produces a superboom on the ground, a cresent-shaped area about one square mile, and the value will lie up in here (indicating) clearly within the damage portion of the curve.

This is another thing they don't tell you about.

Now, I think that we have to look at this figure and think about superbooms in terms of the potential physiological damage to human beings, and there is a gentleman in France—the reference is quoted in the handout here—that has done some work on taking simulated N-waves, subjecting rodents to these N-waves, killing the animals and staining the ear tissue, the cochlea and these have been damaged.

So, in other words, anybody who is going to talk about doing research on the effects of a sonic boom cannot simply sit a human being down, subject him to sonic booms and then measure his hearing afterwards. The kinds of damage that occur are the kinds that will not show up in short-term hearing tests, it will only show up as a chronic illness. And I don't know anybody that is going to volunteer to have his head cut off so that somebody can stain the hair cells inside his ear. You are going to have to work with the complete mammal spectrum to find out what this damage is.

The fact is that we have voluminary evidence that suggests that the sonic boom will cause physiological damage to the hearing system and because of this research is definitely needed before we can release the supersonic planes for overland flight.

Now, I would like to give you another quote, and this says: "Even if one comes to the conclusion that the environment produced by the boom and by the operational schedule of the first generation SST is tolerable and without problems, now would be the time to start study programs to have data available for decisions regarding the next generation or an increased schedule."

I think the important thing to realize here—and this quote was made in about 1966—is that the SST or the approval of the SST is not the end result of a technological change; it is a first step in a series of technological changes. And what I would like to do now is run through my forecast of the events that will follow from the approval of an overland flight of the SST, and then we can sit around and talk about the potential effects of this—physiological, economic, and psychological.

The next slide shows my sonic boom forecast. Basically the first step is the acceptance of the European SST for overland flight over the United States. The second step is a purchasing race for SST's, and I believe that all but three American airlines presently have options for the Concorde SST. (See Slide 2 printed after Dr. Carr's testimony.)

The third step is that the number of sonic booms over the United States will increase as the frequency of supersonic flights increase. The numbers of cities served by the supersonic aircraft will then increase and superbooms will increase as airlanes become crowded.

In other words, you can take a single route and say, "All right, we are going to fly supersonic aircraft back and forth on this route." Now, you put five, six, seven, eight routes—you put all these guys up at 60,000 feet and sooner or later one is going to come close to the other; they are both going to maneuver; and somewheres out over the midwest we are going to get a whole series of superbooms the magnitude of which is kind of a little difficult to predict.

Then, America decides to build its own supersonic transport. Now, presently we have decided not to build one but as soon as the people realize the economics of the situation that we have a European-dominated market, America will, in fact, decide to build a supersonic transport. The American supersonic transport will naturally be larger and faster than the European supersonic transport, and the sonic boom or overpressure levels will increase.

Then what happens is because commercial aircraft are allowed to make sonic booms whenever they please, we will now have the private and the military aircraft that are presently under sonic boom constraint. They will start supersonic flights. And finally we have what is called the HST being developed—the hypersonic transport. I doubt if very many people here have heard about the hypersonic transport. The hypersonic transport will fly at about—

Dr. WHITCOMB. Excuse me just a moment. Could you speak from either side? I can't read the slide, sir.

Dr. CARR. How is that?

Dr. WHITCOMB. Fine. Thank you.

Dr. CARR. We will have the development of the hypersonic transport. The hypersonic transport will fly at speeds of Mach 6 which is 6 times the speed of sound. It will fly at elevations of 100,000 feet, meaning that the width of the sonic boom path will be wider than that for the SST, and for some operational aspects of a hypersonic transport, we will have sonic booms at double the nominal or average value that people are talking about for the supersonic aircraft. So you can see that if we approve the supersonic aircraft for overland flight in the United States that this series of events is not going to be very far behind.

Now, what I would like to do is—oh, if you think the hypersonic transport is sort of a pipedream, you should realize that at the present time, the NASA and the Air Force have a hypersonic vehicle that is undergoing flight testing—it is called the X-24-A. They are unhappy with its characteristics; they are now building an X-24-B so that the hypersonic transport is not something that is 10 or 15 or 1,000 years in the future; it is within the reasonable future given this kind of an economic incentive to go ahead and develop it.

Let's take a look at the physiological effects of sonic booms. The first one is: increased long-term hearing damage. I mentioned before that work has been done with simulated N-waves that produce damage to the nonregenerative hair cells in the ears. This work needs to be confirmed. There is no question about it. There are difficulties with a simulated N-wave. How closely does it match a real N-wave? These kinds of things. (See p. 338)

Basically the work has been done and this work will have to be continued.

The physiological effects of sleep loss are a very important factor for all sonic booms; for the sonic boom overpressure levels that people are talking about for the SST, there is a 10 percent chance you won't wake up if you are sonic-boomed.

The people that—the FAA and others—that talk about approving the SST for overland flight say, "We acknowledge that the loss of sleep will bring the public down on our heads, so to speak, and therefore we are going to confine SST flights to daylight hours."

The problem is that if you have night shift work; if you have military personnel on night duty; if you have small children of napping age, all of these people are going to suffer the very real physiological side effects of sleep loss. And in terms of night shift workers, Detroit is one city that is going to be sonic-boomed, and you can just picture sending in the order for your new car saying "I want one made in the daytime" because you don't know what the guys are doing at nighttime because they haven't slept for the past 3 months maybe.

So this kind of thing is going to affect all kinds of industries that use multiple shift. These people are going to have high absentee rates, perhaps high personnel turnover. You can use your imagination to extend this kind of thing to the economic aspects. Then we will have increases in tension-related diseases. Here I am talking about spastic colons, ulcers, nervous breakdowns. If you have only 10 sonic booms a day, that will be 3,000 sonic booms over a 1-year period, and 3,000 sonic booms to somebody that might be on the edge of a nervous breakdown might just be enough to push them over the line, even if it is confined to the daylight hours.

One of the things that we might mention in here is that the sonic boom, as measured outdoors, is different from the sonic boom measured indoors because the sonic boom indoors shakes the whole building and everything in it and noise levels as recorded inside buildings are actually higher for sonic booms than if you just go out in an open field and record noise levels. So those people working indoors, confined indoors, or who just happen to be indoors most of the time—these are the people that are going to have the largest associated noise effects with sonic booms.

The psychological effects are increased aggression by the general public. I think that there have been plenty of cases where we have already documented aggression triggered by noise pollution. This is certainly going to increase. If you take Detroit and they have a poor year for cars, will the sonic booms contribute to a riot, for instance. That is an interesting question.

You will also have increased aggression by criminals and police, particularly since criminals and police tend to confine their activities to the early evening hours—I assume they have to sleep sometimes; they will probably try and sleep in the morning or the afternoon—these guys are busy being sonic-boomed and they are going to be, as we say, a little uptight about this.

Increased irritation reaction against all forms of noise pollution—the Air Force studies have shown that if you subject a man to noise after his initial adjustment he becomes less tolerant rather than more tolerant of noise in general, and that if you sonic-boom people you are going to find that people living near other noise pollution sources will complain more—such as airports, major highways. It may affect the trucking industry a little bit. They may have to buy bigger and better mufflers because people will complain about highways and they will, in fact, displace their complaint from the sonic boom to other sources nearby that they can holler about and maybe do something about.

At the present time, one adult in eight in the United States would rather live somewhere else. This is a measure of dissatisfaction with the United States. If the sonic boom is allowed to affect 50 million people, I think that we are going to see a pretty big change in this ratio, and that will be a prediction that people can go ahead and measure should we allow the SST to start flying.

Finally, the psychological reaction to sonic booms could easily destroy a career of any elected official of favoring the overland flight of the SST. I myself will never vote for anybody who sonic-booms me or who allowed me to be sonic-boomed, and I am sure that there are lots of other people in the same general boat.

To conclude—and I repeat my conclusions—the proposed overland flights of the supersonic aircraft should not be allowed. I believe that the Office of Noise Abatement and Control should be directing a research effort to documenting physiological and psychological effects of sonic booms and that this data should be presented at the time that the decision will be made, and that decision will be made around 1974 or 1975.

Mr. Shaffer, head of FAA, says that they are working with

European authorities to get the supersonic transport certified for U.S. flight, and that they expect the certification by the end of 1974.

And if the supersonic transport should be approved for overland flight, then we certainly have a host of research problems where funding is going to have to start before supersonic flight, and I think that sums up my presentation.

Dr. **MEYER**. Very good, Dr. Carr.

Your longer statement entitled and identified as "The Physiological, Psychological and Economic Effects of Sonic Booms," by the Lowell Technological Institute Research Foundation, will be printed in the record following the verbatim transcript of your statement.

(The document referred to above follows in its entirety.)

Dr. **MEYER**. At this point, then, we will proceed to ask some questions.

Dr. Botsford.

Dr. **BOTSFORD**. You said that the SST was unacceptable on economic grounds as well as one of your conclusions. Would you elaborate on that?

Dr. **CARR**. At the present time, the forecasts for physical damage that have been made on sonic boom damage—physical damage to buildings and structures and things of this nature—these forecasts range between $35 million a year to $100 million a year. I am not prepared to defend either extreme because I haven't sat down and said this is a reasonable forecast, for instance.

What I am saying is that besides the physical effects of broken windows, cracked foundations, and things like this caused by the sonic booms at the high end of the distribution spectrum, that this is part of it. Another part is this physiological damage and psychological damage, that the people are going to react to this and this is going to have a hidden cost to the public. It won't be so hidden if you can't have night shift operations in sonic boom areas. That is the kind of thing that nobody has given much attention to.

Dr. **BOTSFORD**. Now, just to comment. I think the sonic boom might deteriorate industrial safety. I remember once in a quarry we bought a settling device that accumulated some acetylene in a chamber and it periodically would explode. It would scare away pigeons. The pigeon is a remarkably well adjusted bird and it wasn't bothered by this at all, but it scared our workmen and one almost jumped into a crusher one time, so we had to do away with that.

Dr. **CARR**. There are other effects, too, like I wouldn't want to be on an operating table when a doctor suffered a startle effect while he was starting an incision or something. This could be somewhat disastrous on the person alone.

Dr. **FIDELL**. Well, there is lots of anecdotal evidence of that sort, but I guess I don't have any direct questions.

Just for the record I would like to make some comments. First, I think it is regrettable that the FAA has either acquired or earned its reputation of—well, the fact that people question the sincerity of the government's commitment to no overland SST is regrettable. Perhaps they do so realistically or cynically. In any event it is still regrettable that the FAA has acquired that reputation.

As for the bulk of Dr. Carr's presentation, I think it was perhaps slightly overstated. I don't think that the scare procedures are necessary. Dr. Carr urged us to use our imaginations about the economic import. I don't think you have to. I think there are sufficient grounds for reasonable people to make the decision without being led through all of the horrors that could conceivably come about—and many of them are, of course, anecdotal. In short, the conjecture is not necessary.

The actual economics are themselves a question of great dispute among the columnists. They are questionable at best. It is a high-risk-low-profit sort of venture. The Boeing's bankers, in their infinite business judgment, didn't feel it was worth risking any of their money beyond a certain point on the supersonic transport. It is not clear to me that they are going to make that decision again, and it is therefore not at all clear to me that America will ever decide to build a supersonic transport or a hypersonic transport.

The operating efficiencies of the aircraft are not attractive to airlines on their own basis. Of course, there is a competitive advantage perhaps for one airline or another to purchase the things in a silly sort of purchasing race, as Dr. Carr mentioned.

All in all, I think it is a marginal sort of problem and if one could not even entrust one's government to maintain their position, then perhaps it is perhaps not as much of an issue as Dr. Carr makes it to be.

I think there is a lot of sense and a lot of truth in what he is pointing out, but one needn't be quite as grim and skeptical about it as Dr. Carr is.

Dr. **von Gierke**. I would tend to endorse basically Dr. Fidell's statement about the outcome of the future, and I think that we have some evidence that decisions which were made by the President and by the government are made on the basis of the best information we had available and the best research information which was accumulated over the last 16 years.

I guess our main question now is: what additional research should be done and how it should be done. So one of my questions, Dr. Carr, is: In what particular type of research are you involved, and what research have you done on this overall SST and sonic boom problem which led you to these conclusions, or are these conclusions more or less your opinion as a private citizen?

Dr. **Carr**. No, my research experience in this area has been 7 years experience in underwater acoustics. In this general area I have been turning my attention to—in fact, I did a research project once on acoustic detection of tanks for the army.

In terms of the particular problem here of sonic booms, I have just finished writing a book called "Introduction to Noise Pollution" with specific reference to sonic books and personally—speaking on the personal level now, I have not seen in the press—that is, the material generally available to the public—any mention of a super boom, any mention of a hypersonic transport which was proposed a long time ago, and these are the kinds of things that I am trying to bring to the attention of the general public as well as to the people here that may not be familiar with sonic boom conferences, for instance.

Dr. von Gierke. Well, since you mention hypersonic transport, as far as I know, most people look at the hypersonic transport research project as a way to find a possible solution to the supersonic boom problem.

I understand that the goal is to have supersonic aircraft flying above 100,000 feet and if you solved this technology you would have no boom coming from this altitude to the ground.

Dr. Carr. Well, that is not true. If you go and look at the conferences, you will find that they produce a sonic boom profile all of the time that the craft is in supersonic flight.

Dr. von Gierke. No, I guess this is not correct. I think if you have enough altitude and are above 100,000 feet in space, the boom does not reach the ground any more, and most of the research done by NASA in conection with the hypersonic vehicles is conducted in connection and in support of space flight. And we know if you go high enough into space the shock wave from the vehicle does not reach the ground.

Dr. Carr. Well, the forecast made in the second sonic boom conference held by NASA showed for the entire flight profile of the hypersonic aircraft that sonic booms will be produced.

The other thing is for overland flight they already stated that the hypersonic aircraft won't make any sense because by the time they get up to hypersonic speeds they will be where they are supposed to be.

So the only thing that the people who talk about hypersonic transport are talking about are talking about international flights where you are really going to buy something.

Dr. von Gierke. For the present time, I guess the British and French Concorde are scheduled for transatlantic flight, and it looks to me as if this would be a unique opportunity to study the effect of the sonic boom on marine life, and the ecology in the ocean. And since we probably have not much control over these flights, and they will take place—actually they are taking place now, as we know, from the Concorde flight to South America—it looks to me as if that is an area where the research could be done right now and where it should be done.

Dr. Carr. I want to make my position clear that I had no objection to the supersonic aircraft international flights over unpopulated areas or over the ocean. There is no reason why not to use this technology there. And if you should fly over an island this would give you a perfect research site mass.

Dr. von Gierke. Well, I guess you would want to study the effect on marine life, too, and only after this we could really decide if increased schedule of SST's would be an ecological hazard or not. I think all of these things have to be researched and studied on a logical step-by-step basis before you come to any conclusion.

Dr. Carr. The study of marine life wouldn't really apply very much to human beings because, first of all, it is only the mammal marine life that has our same general type of hearing system; and the second thing is that their hearing systems go up into frequencies much, much higher than ours.

Dr. **von Gierke**. We don't study marine life to draw conclusions to the human being; we study marine life because we are concerned about the environment, the same way because several countries study the effect of the sonic boom on deer, on mink, on elk, and what-not. So I think if the SST is flying over the water, we should study the effect on marine life.

But one comment—

Dr. **Meyer**. Excuse me, if my colleague would yield a minute.

I would like to repeat that, that although most of the evidence reviewed by the Environmental Protection Agency in preparing its report to Congress indicates the magnitude of the pressure effects on the sea surface or substitute appears to have had no significant effects on marine life, Dr. von Gierke highlights something that we all need to keep in mind: we are concerned not just with noise or sonic booms as an isolated phenomenon but as an integrated phenomenon that is part of the total ecosystem. And as Jacques Cousteau and others pointed out, the oceans perhaps being far more fragile than we thought, human life is dependent upon the sea, that anything that affects marine biology and marine ecology also has magnification effects on humans. We cannot become preoccupied with a single event or a single series of phenomena associated with one element of the environment without looking at the totality. I want to endorse what Dr. von Gierke has said.

Goahead, Henning.

Dr. **von Gierke**. I see you used in your statement, quote, that the certification of the Concorde is presently being pursued by the FAA.

If I am informed right, this certification is not with respect to flying overland in the United States but just the certification that the subsonic noise of the Concorde SST would be acceptable to airport authorities in the United States. So it is anticipated that the plane would fly subsonic like any other plane we are operating now over land areas.

Dr. **Carr**. That is correct.

Dr. **von Gierke**. So, since you stated before you were not opposing the SST flying transatlantic over water, I guess this certification effort per se is nothing you object to.

Dr. **Carr**: Well, except that if you have airlines that buy the planes that don't have any overland or overseas flights. Now, this raises an interesting question.

I mean, I have no idea where they planned to use these.

Dr. **von Gierke**. The way the policy is right now, if they buy it they couldn't fly it. If they don't want to fly it over water and they can't fly it over land, they just couldn't fly it. I doubt if anyone would buy it.

Well, I have one final question. I guess you used the statement in your verbal testimony—I can't find it in your written testimony—that there is documented evidence of increased aggression due to noise pollution, and I heard many speculations about this, but I have never seen any real documented evidence on this fact.

Dr. **Carr.** Well, I could dig some up for you. There are two specific cases that I am aware of: one was noise pollution murder in the Bronx; and the second was a statement by the Paris Police Department that they felt that they have at least three cases of noise-pollution-related murders where noise was a factor in driving a person into, shall we say, irrational or antisocial behavior to the extent where they killed somebody.

Dr. **von Gierke.** Well, probably both cases would be better described legally and scientifically as alleged.

Dr. **Carr.** Alleged, yes, maybe; true.

Dr. **Whitcomb.** I share many of your concerns about the sonic boom, but I am dismayed that by overstating them in some of these things you really tend to weaken your position.

I, first of all, would like to comment about the statement that the FAA doesn't speak of either the focusing boom or the true atmospheric conditions or the crescent-shaped acceleration boom. The FAA was beaten about the ears yesterday with regard to airport noise, and so I think somebody should come to their defense now. They do have several reports, as does NASA, in the open literature of where they have funded research in just this area.

One other comment. I found the report you cited on ear damage from a simulated sonic boom to be nearly incredible unless the simulation was only the N-shape but not an attempt to simulate the overpressure level from the actual sonic boom, because everything I know of would indicate that you are something like 2 orders of magnitude less in intensity than would be the threshold for hearing damage, but I would rather have the next panelist, Dr. Eldredge, comment on this.

Dr. **Eldredge.** I think that report is really in the form of a preliminary report and was not very well controlled, as I recall the reference which is here. I have seen it and wouldn't have approved of it.

I have only one additional comment and that is, very quickly categorizing some of the other physical effects of sonic booms, you lumped together breaking windows and knocking knickknacks off the shelf with cracking a foundation, and it would be my impression that these are really quite different classes of physical effects. Did you mean to lump them together, or did you mean that these sound overpressures actually are enough to crack foundations?

Dr. **Carr.** Let's put it this way: The Air Force has paid people for foundations that they have cracked in some of the sonic boom studies, and you know nobody takes a pictures of their basement wall and says after the sonic boom flights have occurred there is a big crack in them. They go down some day and maybe find water leaking in or something like this. So that the whole question of the effects of the sonic boom on the building industry is wide open as far as I can tell.

Dr. **Eldredge.** Thank you.

Dr. **Meyer.** I share some of the concern of the rest of the panel in that although I agree very whole heartedly with some of the fears regarding supersonic flights on a routine basis over the land mass of the United States, that some of the comments, Dr. Carr, in your paper, really fall in the category of either allegation or anecdote, which is perfectly all right so long as they are recognized as that.

One of the things that at least several of us are concerned about in the scientific community is what is called truth by assertion. In other words, things are said so often that that they are just accepted as fact with very little investigation to see what the basis of this assumption is. The basis is actually a fact but it is, in the telling and retelling, accepted in a context different from that in which it is given.

To that extent, then, Dr. Whitcomb, of course, did ask for some comment about the damaged hair cell problem and that has been explained but again somebody from the audience, in line with our rules—since I don't allow direct or cross interrogation of a witness from the audience except through the panel—Would you cite your evidence for the occurence of sonic boom-induced increases in tension-related diseases such as ulcers, spastic colon and other illnesses? A literature citation, preferably.

Dr. CARR. I don't have one with me right now.

Dr. MEYER. Would you furnish it for the record as it would show as a response to this question? (reference and further comments by Dr. Carr are printed following his testimony.)

It was requested by someone in the audience to ask a member of the panel—and I will ask Dr. von Gierke if he would like to reply—to comment on the comparison between the overpressure of sonic booms compared with thunder.

Do you want to comment on that?

Dr. VON GIERKE. Well, first, the sonic boom has much more low frequencies and infrasound in it than thunder, so all the non-auditory effect, vibratory effect, building vibration effect, and so on, you get from the sonic boom you do not get from thunder.

Now, the P-pressures from a good thunderstorm, when you are close to the lightning, certainly can go to the same levels or even higher than the peak pressures of a sonic boom, and the startling effect of lightning is certainly greater than the one from the sonic boom. I don't know what this proves or does not prove, because in general areas where you are exposed to 30 lightnings close to you day and night, as some of the SST schedules have proposed so—I think a comparison with thunder is fine just to show that we are able to tolerate it and tolerate such pressures in our natural environment, but it certainly does not help us to make a decision if we want such noises permanently as part of our daily environment.

But I wonder, Dr. Carr, if you realize—I mean—how many sonic booms are taking place every day in the United States now from military flying, and that everything possible has been done or is being done to study any potential effect from these booms and that most of the things you talked about have not been discovered to this point. But when we had the extensive Oklahoma City tests, where Oklahoma City was boomed for several months on a very intense schedule, we tried to get every possible report from the medical community, from hospitals, surgeons, and so on, just to get comments on the type of speculative effects you mention in your statement, and that if your studies extend the boom reports on these experiments you find that no such effects were reported or found.

Dr. **CARR.** In that particular study, the sonic boom overpressure levels averaged 1.6 pounds per square foot. Now, the proposed for the SST flight is about 2.2 pounds per square foot which is a little bit larger—25 percent larger—and the other thing is they were subjected to 1,250 sonic booms, which is fewer sonic booms than you would be subjected to, shall we say, if you are sonic-boomed 10 times a day. This will be the equivalent of 4 months. Now, 4 months doesn't add up to 3 years or 10 years of side effects.

Let me make just one final comment. In the larger document that I have submitted with the testimony here there are some more specific recommendations on what I would consider research projects that I would like to see the results of.

Thank you.

Dr. **MEYER.** Before going on—because I still have another question—one of Dr. von Gierke's eminent colleagues in the audience has asked him a question which is: Do you believe there is more psychological stress from a source we can control, such as sonic booms, as opposed to noncontrollable sources in nature such as thunder? I might add: such as Niagara Falls.

Would you care to answer that one?

Dr. **VON GIERKE.** Well, as I tried to point out in the discussion of Dr. Weltman's testimony, I think the psychological stress depends to a large extent on your adaptation to this environment, and there is good evidence that man and animals adapt to a very large degree to the strangest environments if they are forced to adapt to them. And I guess many of us who live in a quiet suburban environment, when they come to downtown Boston into a hotel similar to this—I mean they can't sleep the first night, second night, third night, and are probably more disturbed by the traffic noise at 5:00 and 6:00 o'clock in the morning than they would be disturbed by several sonic booms during the night.

So, I mean up to a certain level, all humans and animals adapt to their environment and to the auditory environment specifically. So I think people and animals who live in areas where there are regular thunderstorms—and there are tropic areas where you have a thunderstorm every day—they adapt to this, and we have similar experience with human workers working on jet engines and similar high intensity noise sources where at the beginning when they are unfamiliar with the noise of a new engine, they worry about it, and they are scared, and in many cases the initial response is that the noise bothers them. But after some exposure time and after they are familiar with this particular noise and with their job on this engine, you don't hear any complaints any more, and they are not worried about the noise any more because they adapted to it, and the noise per se doesn't bring any message to them any more. The sound is perceived by the ear but the brain more or less disregards some of the fear contained in the sound, and therefore psychologically the sound doesn't bother the individual so much as a new unexpected sound which is always apt to startle us and alarm us at the beginning.

Dr. **Carr**. May I make one comment on that?

Dr. **Meyer**. Yes, of course.

Dr. **Carr**. The last instance that you quote of an aircraft worker—the sound can be directly associated with something pleasurable such as payday, and that the people who find it dissatisfactory may get up and leave the area. For a sonic boom to occur, most of us won't be able to associate this with payday and to say we are going to be as willing to adapt without the economic incentive, I don't think it is a fair statement.

Dr. **von Gierke**. No, I guess you misunderstood the example I tried to bring. I mean I tried to bring the example that experienced noise workers checked engine mechanics when they are suddenly shifted from working on one aircraft or one engine on another engine, and then they come to their flight surgeon or to their medical department and report "The noise of this new engine bothers me." And then one tries to do everything possible—give him better protection or see if there is anything special in this noise which could worry them more than the noise on their engine they worked on before. But at least in our experience, a large part of this being alarmed by the new type of sound of a new engine is just that they are unfamiliar with this engine and that they worry about the unexperienced new sound clues which are hidden in the noise of the new engine, and by the time they work for certain time periods on this engine they are familiar with it and they don't worry about it any more.

Dr. **Meyer**. I have another question, Dr. Carr.

You made a statement that there is an increase in dissatisfaction with locale situation in the United States—presently 1 adult in 8. Can you give me the literature reference for that?

Dr. **Carr**. I can send that to you when I send you the other reference.

Dr. **Meyer**. I would like to have it because it amounts to something over 25 million people. I resume the reference, then, shows causes of this dissatisfaction, and so on? If that is available I would like to have it. It would be very useful to us because we have been making some studies on potential impact of noise to the population, and it is much larger than has been anticipated by previous studies. I don't want to discuss it at this point.

Yes. Go ahead.

Dr. **von Gierke**. This 1 in 8—is this due to noise or due to just everything—

Dr. **Carr**. Everything; all causes.

Dr. **von Gierke**.—everything put together? Okay. Just wanted to clarify.

Dr. **Meyer**. That is why I would like to have it for the record because it would be very useful information.

Let me say one last thing about part of this problem: You know there is some public concern and distrust of the environmental impact system dealing with implementation of the National Environmental Policy Act, Public Law 91-190. Obviously any route changes or any actions in addition to certification of the supersonic transport would require an Environmental Impact Statement at which time, of course, the Environmental Protection Agency would be involved in reviewing any such proposals. That is why it is absolutely essential that we get both public views, which may have no basis in fact other than that is the way people feel, and also scientific fact. And I think the record clearly should show that we are aware of the importance of both of these things.

Thank you very much for a very stimulating paper, sir. (further comments by Dr. Carr are as follows:

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# THE PHYSIOLOGICAL, PSYCHOLOGICAL AND ECONOMIC EFFECTS OF SONIC BOOMS

By

Jerome B. Carr, Ph.D.

Prepared for the

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## INTRODUCTION

In June of 1971 at the Paris Airshow, John H. Shaffer, Head of the Federal Aviation Administration (FAA) said that "The supersonic plane is an absolute necessity." He further stated that the FAA is working closely with aviation authorities in France and Britain to prepare the Concorde supersonic transport (SST) for U. S. certification. This certification is anticipated towards the end of 1974. Already, some U. S. airlines have acquired purchase options for the Concorde SST.

From this brief introduction, one can see that there are already forces in existence that may eventually result in overland flights of supersonic transports on a regular basis. Once these flights commence, a major portion of the U. S. population will be subjected to sonic booms. It is the purpose of this report to review some of the known effects of sonic booms and to project the development of this new environmental factor into the future. Knowledge of the potential long term effects of the sonic boom should be valuable in protecting the public from a new environmental pollutant and will aid in defining priorities and research needs for the Office of Noise Abatement and Control within the Environmental Protection Agency.

## THE SONIC BOOM

Whenever any aircraft flies faster than the speed of sound, a sonic boom is produced. When a plane designed for supersonic flight flies at speeds less than the speed of sound, sonic booms do not occur. Thus, international flights of SST's present no new environmental hazard in the area of noise pollution, as long as those portions of the flight path where supersonic speeds are achieved are confined to ocean areas and totally unpopulated regions. Therefore, the question of noise pollution arises only when supersonic flight occurs over populated continental areas.

Before we can begin to investigate the physiological, psychological and economic effects of the sonic boom, we must first understand the nature of the sonic booms generated by high flying aircraft. The first thing to note about sonic booms is that they are shock waves. This means that sonic booms consist of large variations of atmospheric pressure propagating at speeds faster than the speed of sound. When the sonic boom is derived from a high flying aircraft, the resulting shock wave is frequently described as an *N* wave. This means that a tracing of the pressure variation as a function of time resembles the letter *N*. Thus, when a sonic boom occurs, atmospheric pressure rises sharply, then drops gradually to values below atmospheric pressure and then rises sharply back to normal atmospheric pressure. When discussing the pressure of a sonic boom, one always refers to the overpressure, which is the change in pressure recorded during the initial rise in atmospheric pressure. This is the largest pressure change in a sonic boom.

Having established that sonic booms are essentially abrupt changes in atmospheric pressure, one should note two other properties of sonic booms. The first is that the total duration of the sonic boom, as measured outdoors, is about two tenths (0.2) of a second. The other factor to be noted is that most of the energy of a sonic boom cannot be heard by the human hearing system. Thus, when you hear a sonic boom out-of-doors, you hear only the smaller but still considerable pressure variations superimposed on the larger N wave. Unfortunately the sonic boom effects are of longer duration and more complex inside of buildings because sonic booms rattle the buildings and everything in them. The net effect is that noise levels inside buildings will be higher than outside noise levels and thus the physiological and psychological reactions to sonic booms will be magnified for those persons spending most of their time indoors.

Let us now look at the sonic boom characteristics along the flight path of an SST. The first item to note about an SST flight is that the average pressure variation of the sonic boom is related to the altitude of the flight and how fast the plane is traveling. In general, the faster the plane travels--the larger the sonic boom overpressure, and the greater the altitude--the smaller the sonic boom overpressure. Present flight characteristics proposed for SST's will produce an average overpressure at the earth's surface of about 2.2 pounds per square foot (psf). What is important, though, and frequently overlooked, is that refraction (bending) of the sonic boom wave paths in the atmosphere and the nature of the earth's surface influence the final overpressure value of the sonic boom. The result is that the actual pressures recorded will vary about the average overpressure value, and overpressures capable of producing physical damage will always occur somewhere along the flight path. Most of the resulting physical damage will be in the form of broken windows, cracked plaster, cracked foundations, etc., all with an economic value. In terms of predicting physiological damage, all research should be done at overpressure values exceeding the average or design-flight overpressure values proposed as "acceptable" because these higher values will be a very real part of our environment.

To place the preceding paragraph in visual format, a frequency distribution curve of sonic boom overpressure values is presented in Figure 1. Notice that the right side of the distribution curve reaches into the curve representing amounts of physical damage. Note further that as the normal value of overpressure increases, the entire distribution curve will move to the right and amounts of physical damage will increase rapidly. This fact is important to note when considering physiological and psychological effects of sonic booms and in planning for larger and faster SST models.

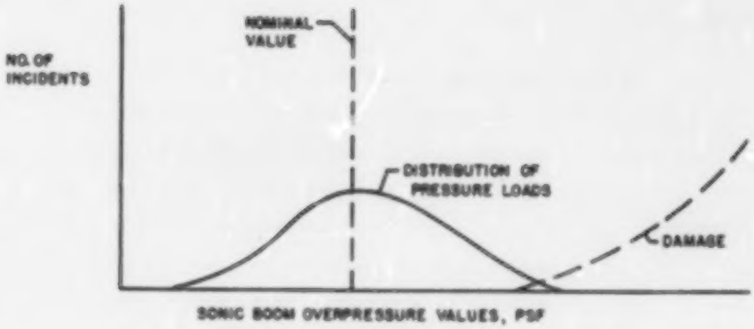

Figure 1. Distribution Curve of Sonic Boom Overpressures along a Flight Path of an SST.

Note that some overpressure values always reach values capable of producing physical damage.

## SUPERBOOMS

There is one aspect of supersonic flight that has been played down by those who favor the acceptance of SST overland flights. That is the creation of superbooms whenever an SST maneuvers at supersonic speed. A superboom may be defined as a very large sonic boom. Superbooms may have overpressure values up to four times larger than the usual sonic booms created by level flight of a supersonic aircraft. Fortunately, the area affected by superbooms is small compared with the usual sonic boom. The area generally affected will be a crescent shaped area covering about one square mile under a maneuvering SST. However, in the superboom area, the overpressure value will be well to right of the nominal value as shown in Figure 1 and the probability of physical damage will be very high. These large overpressures also greatly increase the chances of physiological damage in superboom areas. Note that as SST flights increase in number, the crowding of airlanes will greatly increase the frequency of superbooms as SST's maneuver to avoid collisions.

## WHO WILL BE AFFECTED BY SONIC BOOMS?

Because superbooms must be avoided by SST's, the flight paths of proposed commercial supersonic flights are straight lines on a globe. Given these straight lines and an expected sonic boom reach of 25 miles on each side of a SST route, anyone can create lists of cities that will be subjected to sonic booms for any proposed SST route. Table 1 presents lists of cities that would be subject to sonic booms for eight SST routes. It is interesting to note that these eight routes cause sonic booms in 39 of the 48 continental United States, while affecting portions of Canada, 11 state capitals and the seat of Federal Government--Washington, D.C. These lists were prepared to change the general statement that 50 million people will be disturbed by sonic booms to the more specific statements that "Detroit will be sonic boomed," "Cleveland will be sonic boomed," etc.

THE FUTURE OF THE SONIC BOOM

So far we have established that investigation of physiological damage to sonic booms must occur at the highest expected overpressure value of the *N* waves and not the average value. Now, to evaluate the frequency of sonic booms, a sonic boom forecast is required. Consider the following quote: "Even if one comes to the conclusion that the environment produced by the boom and by the operational schedule of the *first generation* SST is tolerable and without problems, now would be the time to start study programs to have data available for decisions regarding the *next generation* or an *increased schedule*." (Accent mine.)*

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* Von Gierke, H. H., "Effects of Sonic Booms on People: Review and Outlook," Journal of the Acoustical Society of America, Vol. 39, Part 2, Page 544, 1966.

TABLE 1

Lists of major urban areas subjected to sonic booms for eight SST flight plans. The N or S in parentheses means the urban area is north or south of the flight path but still within range of the sonic boom. Cities without an N or S lie directly under the SST flight path and will suffer maximum sonic boom overpressures.

Boston To San Francisco SST Flight Path

Boston, Mass.
Pittsfield, Mass. (N)
Albany, N. Y. (N)
Syracuse, N. Y.
Rochester, N. Y. (S)
Buffalo, N. Y. (N)
Hamilton, Ontario
London, Ontario (S)
Saginaw, Michigan
Milwaukee, Wisconsin (N)
Madison, Wisconsin (N)
Madison City, Iowa
Sioux City, Iowa (N)
Scotts Bluff, Nebraska
Rock Spring, Wyoming
Salt Lake City, Utah
San Francisco, California

Boston To Los Angeles SST Flight Path

Pittsfield, Mass.
Albany, N. Y.
Cortland, N. Y.
Buffalo, N. Y. (S)
Detroit, Michigan
Ann Arbor, Michigan
Battle Creek, Michigan
Kalamazoo, Michigan
Chicago, Illinois
Davenport, Iowa

Boston To Los Angeles SST Flight Path (Cont.)

Des Moines, Iowa (S)
Lincoln, Nebraska
Colorado Springs, Colorado
Lake Powell, Utah
Grand Canyon, Arizona
Los Angeles, California

Boston To Seattle SST Flight Path

Boston, Mass.
Nashua, N. H. (S)
Keene, N. H.
Rutland, Vermont
Saratoga Springs, N. Y. (N)
Watertown, N. Y.
Kingston, Ontario (S)
Marquette, Michigan (N)
Duluth, Minnesota (N)
Grand Forks, North Dakota
Minot, North Dakota
Williston, North Dakota
Havre, Montana
Kalispell, Montana
Coeur D'Alene, Idaho
Spokane, Washington (N)
Seattle, Washington

New York To San Francisco SST Flight Path

New York, New York
Patterson, New Jersey
Scranton, Pennsylvania
Cleveland, Ohio
Sandusky, Ohio
Toledo, Ohio
Southern Border of Michigan
Chicago, Illinois
Aurora, Illinois
Clinton, Iowa
Cedar Rapids, Iowa
Ames, Iowa
Cheyenne, Wyoming
Laramie, Wyoming (S)
Provo, Utah
San Francisco, California

## New York To Los Angeles SST Flight Path

New York, New York
Newark, New Jersey
Bethlehem, Pennsylvania (N)
State College, Pennsylvania
Youngstown, Ohio
Akron, Ohio
Bowling Green, Ohio
Fort Wayne, Indiana
Lafayette, Indiana
Peoria, Illinois (S)
St. Joseph, Missouri (N)
Fort Riley, Kansas (N)
Pueblo, Colorado
Durango, Colorado
Los Angeles, California

## Washington To San Francisco SST Flight Path

Washington, D. C.
Cumberland, Maryland
Fairmont, West Virginia
Lancaster, Ohio
Dayton, Ohio
Richmond, Indiana
Indianapolis, Indiana (N)
Champaign, Illinois
Missouri-Iowa Border
Lincoln, Nebraska
Grand Isle, Nebraska
Sterling, Colorado
Greely, Colorado
Provo, Utah
Ely, Nevada
San Francisco, California

## Boston To Houston SST Flight Path

Boston, Mass.
Hartford, Conn.
Waterbury, Conn.
New York, N. Y. (N)
Patterson, N. J. (N)
Harrisburg, Pennsylvania
Charleston, West Virginia (S)
Florence, Alabama
Monroe, Louisiana
Houston, Texas

# Washington To Dallas - Fort Worth SST Flight Path

Washington, D. C.
Shenandoah National Park
Charleston, West Virginia (S)
Nashville, Tennessee (N)
Memphis, Tennessee (N)
Little Rock, Arkansas
Texarkana, Texas (N)
Dallas - Fort Worth, Texas

Note that the author of this quote acknowledges that both second generation SST's and increased schedules are expected if this area of technology is allowed to grow unchecked. This expectation has gone so far that an eventual extension of the SST has already been named the hypersonic transport (HST). The HST is supposed to fly at speeds of Mach 6 (six times the speed of sound) and altitudes of 100,000 feet. The resulting overpressures are predicted to be double the overpressures for the SST for certain operational aspects. Furthermore, the width of the sonic boom area will increase so even more people will be disturbed. Thus, one can see that acceptance of the SST by the American public will open the door for the HST a few years hence. A possible sequence of events that would lead to the HST are described in Table 2. This sequence of events portrays the background for evaluating physiological, psychological and economic effects of supersonic flight.

For those who believe that the HST will never be developed, they should know that the Air Force and NASA are jointly funding a research aircraft known as the X-24 to investigate the supersonic, transonic, subsonic and landing characteristics of a hypersonic flight vehicle. The first model of the X-24, the X-24A, has already been flown.*

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* Aviation Week and Space Technology, Vol. 95, No. 7, p. 51, August 16, 1971

## TABLE 2

The sequence of events leading to development of Hypersonic Transports (HST) if the SST is accepted for overland use in the United States.

1. Acceptance of the European SST for commercial use in the United States.
2. Purchasing race for SST's by the larger airlines.
3. Numbers of sonic booms increase because number of SST flights increase.
4. Number of cities served by SST's increase. Therefore, the total area affected by sonic booms increases.
5. Superbooms become more frequent as airlanes become crowded and SST's maneuver to avoid collision.
6. Pressure increases to produce an American SST to escape European domination of the market.
7. American version will be a second generation SST, bigger and faster than the Concorde. Sonic booms become larger.
8. Private and military aircraft begin to operate at supersonic speeds. Sonic boom frequency rises sharply.
9. To take over international markets, the second generation SST is not suitable. Therefore, the hypersonic transport is developed at a cost of billions.

PHYSIOLOGICAL EFFECTS OF SONIC BOOMS

The physiological effects of sonic booms that will most likely concern most people as individuals are (1) the potential hearing loss associated with sonic booms, (2) physiological effects derived from loss of sleep, and (3) increases in tension related diseases.

In the first area, we must acknowledge that those persons subjected to sonic booms apparently show no short term loss of hearing. However, there is research evidence that hair cell damage does occur in the cochleae of sonic boomed animals.* This breakdown of nonregenerative tissue, vital to the hearing system of mammals, is only measurable in the initial stages by killing the mammals and examining the tissue under the microscope. Thus, there is a high possibility that subjecting human populations to sonic booms will yield or add to their long term hearing loss. One must note that just because a few sonic booms produce no measurable hearing loss that tens of thousands of sonic booms will have the same negligible effect. Over 10,000 sonic booms will occur in a three-year period in any city subjected to only 10 sonic booms per day. If restrictions are removed from commercial and military aircraft, this 10 per day figure could easily rise to very high levels for some cities under highly trafficked routes. The occurrence of superbooms will add to this problem as will high level noises triggered inside buildings by sonic booms.

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* Majeau-Chargois, D. A., et al, "Sonic Boom Effects on the Organ of Corti," Laryngoscope, Vol. 80, No. 4, pp. 620-630, 1970.

Thus, until it has been proven conclusively that the human hearing system is not affected by sonic booms, the Government of the United States would be irresponsible in allowing overland flight of SST's. Here is one research area in physiology that must be funded at the federal level if serious consideration is to be given to overland flight of the SST.

The second area of physiological importance to the general public is sleep loss. This general area of sleep loss affects not only man's physiological functions but also has psychological and economic impact. The first factor to be noted in this general area is that an individual has only a small chance (about 10%) of sleeping undisturbed through a sonic boom. Thus sonic booms, even if confined to daylight hours, will affect night workers, military personnel on night duty, nap age children and those who are recovering from illness. Night workers on a fixed shift will suffer the most. After two or three months, it should be possible to measure the effects of sonic booms on productivity, absenteeism, accident rates, and personnel turnover of night workers. If the sonic boom is going to affect body functions of these personnel and their work efficiency, then the hidden economic costs of lower productivity for night workers at a low frequency of occurrence of sonic booms may escalate to the not so hidden costs of abandoning nighttime production runs as sonic boom frequency increases. This suggests a new line of research in investigating the effects of sonic boom generated sleep interruption on production workers and military personnel.

The effects of sonic boom on nap age children is a wide open question. It is strongly suspected that the psychological effects will be more easy to document than any physiological effects. However, one could speculate that increased tension rates could affect hormone balance with resulting subtle changes in growth rates.

It is well known that noise levels in hospitals influence recovery rates from illness and disease. In sonic boomed cities, any effect of sonic booms on recovery rates will be reflected in duration of absences from work and school as well as an increase in length of hospital stays when compared with control cities that are not subject to sonic booms. In all of these sleep loss related effects of sonic booms, there should be a relationship between the frequency of sonic booms and the ability to measure the effects. Thus, in the initial stages of overland supersonic flight, the effects may not become apparent until the frequency exceeds 5 or 10 sonic booms a day.

The third area of general concern is tension related illness such as spastic colons, stomach ulcers, and spontaneous abortions. The frequency of these diseases and the time for recovery from these diseases may correlate directly with sonic boom frequency. Here a host of research projects suggest themselves if sonic booms are to become an everyday occurrence over major populated areas.

## PSYCHOLOGICAL EFFECTS OF SONIC BOOMS

The psychological effects of sonic booms will largely duplicate the general psychological reactions to other forms of noise pollution. The psychological effects will fall into the general categories of:

Annoyance
Antisocial Behavior
Chronic Mental Illness
Acute Mental Illness.

In the area of acute mental illness, both American and European police have documented noise caused acute mental illness that have resulted in noise pollution murders. This type of event is presently rare but nervous breakdowns are not so rare. Thus, we should be prepared to measure changes in nervous breakdown statistics if sonic booms are to occur over populated areas.

Chronic mental illness also appears to be related to noise levels. In Europe, research scientists of several nations have documented statistics on mental hospital admissions in areas near airports that demonstrate that noise is directly associated with chronic mental illness. If sonic booms become a permanent part of our environment, then admissions to mental hospitals will increase, particularly in urban areas already associated with significant noise levels.

Antisocial behavior is also related to noise pollution. This result of noise pollution springs from the general effect of noise increasing aggression. The results of increased aggression may be measurable in the number of family fights, number of assaults, amount of child beating, and finally in riot situations.

Annoyance is the last psychological reaction to be considered here. This annoyance will produce two or three significant effects. The first effect is that the sonic boomed population will be more irritated with, and react more strongly to, all forms of noise pollution. This is easy to understand when you consider the results of the Air Force study that showed that after initial adjustment, people become less tolerant of noise rather than more tolerant. This decrease of tolerance may result in displaced action against other forms of noise pollution. Thus, sonic booms may trigger greater complaint activity against traffic noise, the trucking industry or local airport operations.

The second way annoyance may express itself is in general dissatisfaction with the United States as a place to live. At the present time, one adult in eight in the U. S. would rather live somewhere else other than in the United States. This is the lowest figure in the western nations surveyed. However, if sonic booms are allowed to affect a significant portion of our population, this ratio of 1:7 could rise sharply and result in internal population shifts within the U. S. or could even result in changes in emigration figures.

A third psychological effect of annoyance with sonic booms will result in voter action. Voter dissatisfaction in sonic boomed areas could be sufficient to destroy the political career of any elected official favoring overland flights of supersonic aircraft. It should be noted that one or two sonic booms per day may produce effects that are too subtle to measure or which are below the critical levels for public action. However, eight or ten sonic booms a day could produce measurable results and measurable public reaction.

## CONCLUSION

Based on the projection of events following acceptance of supersonic flight for cross-continental purposes, the following recommendations are made to the Office of Noise Abatement and Control.

Recommendation 1. That every effort be made to prevent acceptance of the SST for overland flight in the United States This should be based on the known effects of noise pollution and the presently unquantified effects.

Recommendation 2. Immediate research efforts should be directed towards documenting damage to mammals' hearing systems by real world sonic booms. This will require animal populations in exposed and control groups and will demonstrate the viability of action undertaken under Recommendation One on public health grounds.

Recommendation 3. An effort should be made to define anticipated SST routes and to begin public education programs in these areas. These efforts should peak just before the 1972 and 1974 elections as an informed population will never allow a sonic boom environment, given our present lack of quantitative knowledge on sonic booms and their effects.

Recommendation 4. If it becomes apparent that the SST will be forced on the American public (or arrive through their inertia), research programs should be initiated before the sonic booming to investigate rates of

spontaneous abortions,
family aggression,
crimes of violence,
divorce statistics,
mental hospital admissions, and
any other parameters that may reflect
psychological impact of the sonic booms.

Recommendation 5. Concurrent with the research mentioned above, research should also be initiated to evaluate the economic effects of sonic booms. Night worker studies should concentrate on job absenteeism, accident rates, rates of rejects from the production lines, and personnel turnover.

Recommendation 6. Special long term research projects should be funded to investigate the psychological effects of sonic booms on children under five years of age. Measurement should include parameters effective in measuring aggressive behavior, learning capabilities, irritability, loss of sleep, and nervous disorders.

Given these kinds of action and research, funded at adequate levels, we should be able to document the adverse effects of sonic booms and to KEEP AMERICA QUIET.

SLIDE 2

## FORECAST OF SONIC BOOM POLLUTION

1) ACCEPTANCE OF EUROPEAN SST FOR OVERLAND FLIGHT

2) PURCHASING RACE FOR SST's

3) NUMBER OF SONIC BOOMS INCREASE AS SST FLIGHTS INCREASE

4) NUMBER OF CITIES SERVED BY SST INCREASES

5) SUPERBOOMS INCREASE AS AIRLANES BECOME CROWDED

6) AMERICA DECIDES TO BUILD SST

7) LARGER AND FASTER AMERICAN SST INCREASES SONIC BOOM PRESSURE LEVELS

8) PRIVATE AND MILITARY AIRCRAFT BEGIN SUPERSONIC FLIGHT

9) HYPERSONIC TRANSPORT DEVELOPED

SLIDE 3

PHYSIOLOGICAL EFFECTS

- INCREASED LONG TERM HEARING DAMAGE
- PHYSIOLOGICAL EFFECTS OF SLEEP LOSS FOR
    - NIGHT SHIFT WORKERS
    - MILITARY PERSONNEL ON NIGHT DUTY
    - SMALL CHILDREN OF NAPPING AGE
- INCREASE IN TENSION RELATED DISEASES

PSYCHOLOGICAL EFFECTS

- INCREASED AGGRESSION BY GENERAL PUBLIC
- INCREASED AGGRESSION BY CRIMINALS AND POLICE
- INCREASED IRRITATION AND REACTION AGAINST ALL FORMS OF NOISE POLLUTION
- INCREASE IN DISSATISFACTION WITH U.S.A. (PRESENTLY ONE ADULT IN EIGHT)
- PSYCHOLOGICAL REACTION TO SONIC BOOMS COULD EASILY DESTROY CAREER OF ANY ELECTED OFFICIAL FAVORING OVERLAND FLIGHT OF SST

## ADDENDUM TO THE TESTIMONY OF JEROME B. CARR

Q. Dr. Meyer asked if I could supply a reference on the fact that one U.S. adult in eight would rather live outside the United States.

A. My reference is a summary of a Gallup Poll presented in the March 21, 1971 edition of New York Times, Page 68, column 3. This reference states that 1,571 adults were interviewed in more than 300 scientifically selected localities. The results indicated that 12 percent of the adults would settle in another country if they were free to do so. This 12 percent figure is double the results of a similar survey performed in 1959.

Q. Dr. Meyer asked if I could document evidence of tension related illness caused by noise.

A. My reference is the Report of the Medical Subcommittee, "Toward a Quieter City—A Report of the Mayor's Task Force on Noise Control—New York City—1970." This report is available at $1.75 per copy from:

Mayor's Task Force on Noise Control
c/o New York Board of Trade
295 Fifth Avenue
New York, N.Y. 10016

In this report, on page 23, it is stated:

"Anxiety, constrained and explosive rage, disturbed sleep, irritability and concentration and energy draining tensions are direct and preventable results of noise in our community. *They are clinically, if not statistically, demonstrable* and in terms of the mental health of our community, should be attacked through legislative and educative measures." (Accent mine.)

Note that clinical evidence of noise related tension is present in our population and *de facto* contributes to present tension related illness. Therefore, it does not seem unreasonable to predict increases in tension related diseases for overland SST flights. Furthermore, it appears that evidence of such noise related illness is not widely available to the scientific community because of lack of time to publish by the practicing medical community. This indicates that one specific recommendation should be added to the list included in the backup document submitted with this testimony.

*Recommendation 7.*—That a survey be made of practicing members of the medical community to document actual case histories where noise was a significant or dominant factor in tension related illness.

In addition to answering those specific questions, I wish to add the following two comments to my testimony.

Dr. VonGierke stated that the hypersonic aircraft would not produce a sonic boom at altitudes of 100,000 feet. In the "Second Conference on Sonic Boom Research," NASA publication SP-108 (available for $1.00 from the U.S. Government Printing Office) on page 60, the mission profiles for the SST and HST are presented. The entire mission profile for the HST produces a sonic boom including those portions of the flight path at altitudes over 100,000 feet.

Dr. Meyer commented on the present ban of overland SST flights and other later testimony implied that overland SST flights are a dead issue. Proof that the overland sonic boom is not a dead issue lies in the following quotes:

"In summary, the full range and depth of the effects that would be created by a fleet of supersonic transports constantly generating sonic booms are very difficult to predict. While some studies suggest that these effects would be minor, others suggest that there would be considerable irritation among people subject to the daily booms. The effects of the booms on animals and natural formations are not fully understood and are under investigation. The Federal government has indicated that *until* such answers are obtained that permit civil overland supersonic flight without unacceptable deterioration of the environment, such flights will be prohibited." ("The Noise Around Us—Including Technical Backup."—COM 71 00147, Department of Commerce, Sept. 1970, Page 97.)

Note that the prohibition is temporary and that the issue will be subject to review. Considering that President Nixon is quoted as saying:

> "In 1980 you will go from Washington to Los Angeles in an hour and a half—that's how fast we'll be moving with the new planes that will be available then," (New York Times, August 26, 1970, Page 26, Column 4),

this implies that the overland sonic boom prohibition stands on weak ground.

This issue will certainly be opened when the air transport industry feels there is some economic advantage to remove the ban. As the SST will be commercially available about 1975, the recommendations I made are viable for your planning purposes.)

Dr. **Meyer**. At this point, again, I should like to ask if Dr. Dougherty of the School of Public Health of Harvard has arrived yet. Dr. Dougherty, would you like to come forward and give your testimony? We would be very happy to have you.

Proceed, sir.

## STATEMENT OF DR. JOHN DOUGHERTY, SCHOOL OF PUBLIC HEALTH, HARVARD UNIVERSITY, CAMBRIDGE, MASS.

Dr. **Dougherty**. I want to thank the panel for the honor of being asked to speak here.

I am Dr. John Dougherty, Assistant Professor of Environmental Health and Safety at the Havard School of Public Health. I am presently in charge of the hearing conservation program of the Massachusetts General Hospital at Logan Airport in East Boston, Massachusetts. For the past 8 years I have worked to limit the harmful effects of noise as an employee of the Federal Aviation Agency on FAA study teams or as a member of the research and teaching staff of the Harvard School of Public Health.

For an orderly presentation, this review of the extra-auditory effects of noise will be presented first with regard to the short-term physiologic and apparently reversible effects of noise. Next we shall turn to longer term and usually irreversible effects of noise. Common links between the two will be covered next followed by important gaps in our knowledge of the extra-auditory effects of noise in man.

The short-term physiologic responses to noise—and here we are speaking of extra-auditory effects solely—are quite similar to those found with emotional stress in animals and man. The similarities have been documented by recording change in blood pressure, pulse pressure, heart rate, perspiration, widening of the pupil, or change in fetal blood flow. When blood or urinary hormone levels are assayed, noise again causes changes similar to those of emotional stress. Blood levels of long-acting hormones such as adrenocorticords (from the cortex of the adrenal gland) are increased by noise. Levels of shorter-acting (adrenalinelike) hormones from the center of the adrenal and from nerve endings are also increased.

To some extent the quality of this response may vary with the emotional content of the noise, with the decibel level and with its frequency. For the most part though, the major variation is found in the strength of the response, and the strength is primarily related to either the dB level or the emotional content of the noise.

Emotional content of noise is a function of several variables. Among them are the individual's previous experience with or prejudice toward a noise, the frequency, band width and rate of change of this change, the amount of startle associated with the noise, the degree of interference with activity, the amount of background stress already experienced by the listener, and the emotional health of the listener. These will play a role in the amount of emotional discomfort which the listener feels. However, even without any awareness of an emotional or physiologic response (in some cases when anesthetized), the listener will manifest most of the physiologic responses noted above. Clearly the willingness of an individual to cheerfully accept noise stresses is no guarantee of his immunity to extra-auditory effects.

Animals which are exposed to chronic noise stress develop much the same disorders as are associated with emotional stress in humans. Diseases such as arterial hypertension, arteriosclerotic vascular disease, myocardial infarction, emotional instability and birth defects have been caused by experimental noise exposures in animals.

Several experiments have been performed which show the similarity between noise and other forms of stress in the genesis of stress-related disease. In general, the same hormonal and central nervous system pathways are involved. When these pathways are stimulated at various points along the chain by quite different agents, the pathologic results are the same. I have not found an experiment which described a dose-relationship between noise and pathologic effects. However, when stimulation of central nervous system pathways of animals was held to the same level of physiologic response as seen in humans with 70–80 dB white noise, marked arteriosclerotic change occurred in animals fed atherogenic diets. These changes were not seen with the diet alone.

Increased rates of a number of disease processes in workers subjected to industrial noise have been described in the Russian literature. In general these studies have not been well controlled. Slowed rates of growth and development have been noted in childrn living near large Japanese airports, but controls were not included to correct for other factors such as socio-economic status.

As an aside, oftentimes these factors can be quite important. People who live near the airports may not have the same diet as people who live away from the airports. The need for well-controlled human studies is further supported by the lack of experiments performed with animals which—like humans—have phlegmatic response to noise. Studies of the effects of noise stress on animals such as dogs or primates would provide valuable evidence for or against the role of noise in stress-related human disorders. I have found only one such study which reported the effects of noise on swine. The authors reported that these animals appeared to adapt to 120 to 130 dB intermittent recorded jet aircraft noise. No effects upon mating or parturition were reported. However, the experimental design was not adequate to create or test for an increased rate of birth defects. The investigators in this study did not search for the appearance of other forms of stress-related disease. The absence of a causal link between noise and stress-related disease in noise tolerant animals and the paucity of well-controlled studies of human exposure constitute the greatest weaknesses in any attempt to indict noise as a cause of stress-related disease in humans.

I have found only two studies which have clearly linked noise stress to human extra-auditory disorders. In one, performed on hospital patients, those recovering from myocardial infarction experienced 3 to 4 times larger adrenergic hormone outputs following a standard noise stress than other hospital patients. The second paper dealt with admission rates to mental hospitals from equivalent socio-economic groups with the only known difference being the flight paths to and from Heahtrow Airport. This airport is near London, England. No significant differences between noisy and quiet areas were found in various subgroups of the population except in older single women who had the highest rate of admission in the quiet areas. Admission rates for this group were significantly elevated (still higher) in the noisy areas. These studies are interesting because they both demonstrate a heightened susceptibility to noise in groups of people who have demonstrated an increased susceptibility to stress-related disease. These studies underscore the need to consider noise stress as only one of a number of variables each with an independent contribution to the overall total physical, emotional and biochemical stresses.

I might make another aside. For example, studies have been performed which show that over half of the variability in the death rates from one county to another from myocardial infarction can be explained on the basis of the atmosphere cadmium level. What this means in terms of cause and effect isn't clear, but when you can explain half the death rate from one county to another on the basis of a variable such as this—if you want to study the effect of noise on death rates from one county to another—it would be, I think, quite important not to leave cadmium out. This, of course, makes the research to be difficult.

When I begin to speak of future research needs, I find a number of areas that I would suggest future research be concentrated upon.

First off: Do noise-tolerant animals such as dogs or monkeys develop stress-related disease or birth defects after exposure? If so, what is the relation between noise levels, frequency, band width and off-on time fractions?

What role does the aging process play in effects of noise on animals or human stress-related disease?

What are the effects of noise upon individuals with pre-existing disorders such as arteriosclerotic vascular disease, diabetes or emotional illness?

What is the relative importance of noise stress among other environmental stresses such as automobile driving, excitement or anger, diet or biochemical stresses such as atmospheric lead or cadmium?

Clearly such research would be multivariant, would require a number of years to perform and would be clostly. However, control of environmental pollutants is costly and should be based upon a priority ranking derived from an estimate of the relative costs or benefits of each dollar spent for control. Research such as that which I have proposed is seldom performed today. Emphasis for funding is upon quick answers, and the more comprehensive a proposal, the more likely that some portion of the study design will offend one or another member of the reviewing committee who ranks proposals for funding.

What is needed is a new emphasis for research to require that the answers do not simply identify an offending stress but also provide an estimate of the importance of the stress relative to other stresses which also appear to require control. A reshaping of the Federal Government's interests toward comprehensive investigative needs would be followed by a similar response from the scientific community.

Dr. **MEYER.** Dr. Dougherty, thank you very much for pointing out again a think the chairman is most concerned about: the need to keep in view this as a multi-variant problem. I would like to, before making any comments, ask Dr. Eldredge if he has any comment?

Dr. **ELDREDGE.** No, I think not.

Dr. **WHITCOMB.** I would like to comment positively on an excellent presentation.

There was a point where you were talking about stimulation of central nervous system pathways of animals was held to the same level of physiological response as seen in humans with 70 to 80 dB white noise, and there was a marked change that occurred in the animals that were fed the atherogenic diets.

Dr. **DOUGHERTY.** Do you want me to elaborate on that?

Dr. **WHITCOMB.** No. What I would like to know is, with regard to that statement, what were the animals, and was marked change what we would call statistically significant?

Dr. **DOUGHERTY.** To describe this experiment a bit, the central nervous stimulation was with electrodes implanted in the animal's brain in the hypothalamus. The level of physiologic stimulation was to the point where they could just detect widening of the animals'—who happened to be rabbits—pupils without any apparent change or detectable change in the blood pressure of the animals.

The levels of marked arteriosclerotic change were statistically significantly greater than the other control animals that the arteriosclerotic material was extracted with solvents and the amount of cholesterol fats and similar substances were weighed and assayed, and considering the amount of variability between the two groups, why there was a statistically significant increase in arteriosclerosis in the stressed animals.

Dr. **WHITCOMB.** And for how long were the electrodes implaced? Were they chronically implanted?

Dr. **DOUGHERTY.** I don't recall, but my memory says that it was a matter of weeks.

Dr. **VON GIERKE.** I have no particular question. I think this is a very well composed and very well balanced statement of the problem and of the needs for additional research, and I fully endorse the statement that most of our research programs try to get the answer too quick and are not laid out over a long enough time period to give us answers to these questions which are really questions to the chronic effects of noise as we discussed already in connection with several presentations this morning.

So I think your recommendations are very well prepared and very, very sound.

One question perhaps with respect to the relative importance of noise stress compared to other stresses—and this to me is probably the most critical and the most difficult part of a research program in this area: What do you use as a reference stress, so to speak? How can you evaluate comparatively the noise stress to the stress, as you indicate, of driving an automobile, of just working 8 hours per day, and of going through all the other emotional and physical stresses we go through in our modern society?

So I think a research program should be laid out from the start to give the relative importance of these various stresses?

Dr. DOUGHERTY. I don't think I would be competent to design a study to accomplish that end. I recommend that it be done. I don't think I could do it. I think it could be done. I think it would be of importance enough to be a national priority, and the sort of thing that a national study team could be recruited to both design the study and to accomplish it.

Dr. VON GIERKE. But if you don't design the overall study towards this goal, I mean we know at some level of noise you will get some effect on the animals. I mean there is no question about it. Like with every stress, if you go high enough with the stressor, you get some detrimental effect practically on every physiological system. So the real answer is in the relative importance.

Dr. DOUGHERTY. That is right.

Dr. FIDELL. I would like to concur with all of the panel members and Dr. Dougherty once again on all of the points he has made, but perhaps amplify one or two of them because I think he may have been somewhat modest in his approach and also make a few comments and try to get your comparison on some comments I made earlier.

To start off with: As for your point that the sorts of studies which would be most fruitful are not conducted, I heartily concur. And I think the answer might lie perhaps in the examination of the payoffs for the holders of the purse strings who actually do grant these funds and perhaps tells something of the sociology of the research community. If you are a person who is charged with the responsibility at some Federal agency with conducting a research program, it looks good for you—come up with a spectacular finding rapidly—and if in order to do that you must fund a good deal of research which would not be respectable in its own right, research which is characterized by a low probability of a highly startling finding, then that is all too frequently the case that that sort of research is conducted, and I think that is reprehensible.

Secondly, I think I would also amplify your comments about the sort of correlational evidence which is presented many times for the effects of noise on people. You speak in particular about the Heathrow study in which there is some basis for believing that there were adequate controls. Once again, however, it is correlational evidence, and I remind the audience that correlation does not constitute cause. You can correlate the number of schizophrenics with the number of architects, and it works out very well because architects live the same place as schizophrenics do in the big cities, and even that is a fallacy to say because—correlation is not cause and one must keep that in mind.

Then, you made the point which you have never found an experiment describing dose relationship between noise and pathology, and you go on further and say: "The need for well-controlled human studies is further supported by the lack of experiments performed . . . ."—and so forth. And my point about that is I think there is a reason that you have never found such an experiment and that the need for well-controlled studies is important, and that reason goes back to some comments I made, I believe, before your arrival, in which I said that it is my opinion that measurement in the absence of theory is meaningless and perhaps worse than meaningless it is also worse than useless because it wastes time and effort, and that perhaps more time ought to be given to thinking what we should do rather than going out and doing the research.

I was wondering if I could obtain any concurrence from you on that point.

Dr. **Dougherty**. Well, I like to think that studying the effects of noise as a potential cause of stress-related disease in primates wouldn't be an experiment done in the absence of theory. With the number of experiments that have been done showing that noise-sensitive animals such as rats and rabbits, and so forth, develop stress-related disease, I think it is time we quit doing experiments on rats and rabbits and we pick an animal quite close to man in answer to the question: Do higher order animals such as primates develop stress-related disease when exposed to noise? I think it would be an experiment with some basis in theory.

Dr. **Fidell**. Okay. Thank you.

Dr. **Meyer**. Well, I find, as I have said before, this paper is a very useful one, and it focuses attention on one of EPA's needs, which must be met if we are going to do our job, namely the structuring of a good research program which investigates some of our unanswered questions.

And I would like to ask you, based on your experiences, a question. From your viewpoint, both with the Harvard School of Public Health and conducting field activities for Massachusetts General Hospital, what opportunities do you see for some observations and more precise recording of human response, particularly in regard to such things as hearing losses in young, new employees building up out of the vast amount of occupational health data that has accumulated by activities such as you are associated with, and attempting to, in a meaningful way, extract some correlations of information?

Dr. **Dougherty**. Well, I think there are some potentials here. There are a number of ways that you could perform ethical and worthwhile studies on human beings with regard to noise exposure. It is not certainly settled whether you are harming people or helping them. You activate their central nervous system to some extent by giving them a noise exposure. They don't fall asleep as easily, and so on. So, there are a number of ways.

For example, in housing areas controlled by a housing authority where one area—part of a housing area—is quite noisy and one area is relatively quiet, if on some randomly assigned basis you would assign people, for example, to live in one part of the area versus another, particularly in those that are covered by some comprehensive medical scheme, with just a little bit of extra expense a lot of times you could piggyback what is an on-going medical support activity and add the variables you want to study. That is an example.

Similarly, in industry, if you were to have a large enough industry in cooperation from the personnel department of a large industry so that you could randomly assign now people without the personal bias involved in the noisy and non-noisy occupations, and you are willing to sit back and wait 5 or 10 years for the harvest, you see, well, then you could answer a lot of these questions.

Dr. **Meyer**. Let me ask you another question.

Yesterday we heard a tremendous amount of testimony about problems associated with East Boston, and I am wondering if you have any information as to the number of employees that are involved in the hearing conservation program in Logan Airport who are long-time residents of East Boston. Let me be specific as to what I am leading to—the possibility of profile studies starting with the audiogram of the school child in the school system and following them right on up into employment and also extracting, as they go along, the other information about physical condition which would be associated with the occupational health program.

What are your feelings about this?

Dr. **Dougherty**. I have always been a little bit afraid of trying to perform a scientific investigation of this sort in this community—the Boston area—and not just particularly with relation to East Boston. The reason that I have been afraid to do it is that Boston is a community with some sharp ethnic boundaries and very sharp socio-economic boundaries, and I am not altogether sure I could convince anyone when I finish doing the study that I had controlled for this.

There are some ways, I thought, that you could cut across these boundaries. I think it might be interesting to look at things like the effects of noise on postmen in Wellesley, or postmen in downtown Boston, if you could somehow see to it that postmen are about the same, and they live someplace else perhaps. They are all out on the street. There are ways that I think you might be able to get around it. But this Boston area, I think, is a very difficult target community to handle that kind of a study.

Dr. **Meyer**. Let's lift our sights, then, from Boston and go at this on the national level, for which I am responsible. There are other areas of the United States—

Dr. **Dougherty**. That don't have this problem.

Dr. **Meyer**. Do you feel it would be useful to maybe do the same thing both in a place such as you have described with these sharp boundaries and those in which they are not so sharp and compare? You might learn a lot if you did it in two or three different places.

Dr. **Dougherty**. Yes, if you found the same thing irrespective of the socio-economic patterns and the same results kept coming up, why, then, you might start worrying a lot less about the problems I have raised.

Dr. **Meyer**. Yes, sir.

Dr. von Gierke, you apparently had a question, sir.

Dr. VON GIERKE. Our hearing is focused primarily on environmental noise, the noise you are exposed to outside your occupation, and we did not really talk too much about occupational exposure.

Now, some of the pathological or physiological effects we are discussing—and you discussed in your paper—might be more evident in some of the occupational exposures, where people are exposed to high noise levels for years on their jobs, and I wonder if you have any comment about what you think is known and proven to this date about long-term occupational noise effects on the cardiovascular system and the nervous system. I am sure you are familiar with Dr. Jansen's studies in Germany, and Dr. Rosen's studies here in this country, and how do you think the evidence is in this area, that noise contributes to cardiovascular diseases and nervous disorders?

Dr. DOUGHERTY. I don't think that the studies that I have read which describe potential association between stress-related disease and noise in industry persuade me to believe that there is a great problem there. But I don't know that I would expect them to because you have a choice when you go to work as to how much noise you are going to be exposed to, and certainly Jansen has shown that anxious, neurotic people don't tolerate noise very well. And other studies have shown that anxious, neurotic people get stress-related disease, so we have got good evidence, if it is inferential, but good evidence that people who are likely to get stress-related disease are going to "opt" out of noise-related occupations, and therefore the industrial exposure—unless you have opportunity for random assignment and some method of encouraging a man to stay in the noise, although he might complain a little bit about it, you are not going to get, I don't think, the answers that you are thinking of, Dr. von Gierke.

Dr. VON GIERKE. Thank you.

Dr. MEYER. Thank you very much, Dr. Dougherty.

At this point, then, I should like to invite Dr. Paul Borsky if he would come forward. Dr. Borsky is from the Department of Environmental Hygiene of Columbia University, New York, New York.

Welcome, Paul.

Dr. BORSKY. Thank you.

## STATEMENT OF DR. PAUL BORSKY, DEPARTMENT OF ENVIRONMENTAL HYGIENE, COLUMBIA UNIVERSITY, NEW YORK, N.Y.

Dr. BORSKY. Actually, as you know, I had prepared a presentation that would have been given last Thursday in New York. It was kind of geared towards surface transportation. I have broadened it somewhat and I think it probably will be of some pertinence and of interest to the group.

As you know, most of the research, as your program statement indicates, has been on aircraft noise, although there is some information from the social survey data with which I have been associated for some 20-odd years that give you the contextual relationships that Henning was talking about before and which

I firmly support, that noise is one of the environmental stressors, and to be fully understood and not distorted, it has to be seen in the total context of living in modern environments.

Dr. MEYER. Yes, and we are glad that you are bringing that in, and for the record, Dr. Borsky's submissions will appear in the record following his verbatim transmittal.

Dr. BORSKY. Now, during this past summer, I had the opportunity of participating in two workshops in Stockholm, one at the Karolinska Institutet—which was cosponsored by the EPA—Dr. Barth was the representative there—in which I had the opportunity of preparing a chapter of a forthcoming book on methodology which outlines a conceptual framework. We get some theory as to how human beings react in various ways to a stressor situation. And I will leave with you a copy of this statement, and I would like to go over some of the highlights verbally with you.

Dr. MEYER. Very good. That also will appear in the record following the verbatim transcript.

Dr. BORSKY. Secondly, I had the opportunity, since I was—the second conference was on sonic booms and I prepared a chapter of a forthcoming issue of "Sound and Vibration," I understand, which summarizes, as far as we could get, the state of the art, knowledge on human responses to sonic boom.

Now, thirdly, being in Europe, I didn't want to waste any opportunities. I had some support from DOT and I spent some intensive weeks with people at the Institute of Sound and Vibration in Southampton, and after a good deal of effort we have come up with some new information on survey data which makes compatible British and American experience including the new Heathrow II Study which has just become available in print, and I will present some of those findings today to you. I have not gotten it written down in any form that I could give it to you. Such that I propose to give you the conceptual framework, some of the findings, and then a few comments, if I have time, on some needs for additional research in filling gaps.

First, on the conceptual framework, very briefly, of course, you have to start with the stimulus—with the noise stimulus. This document is not framed in terms of, incidentally, noise alone. We started out with noise, because this was the area in which I had the greatest familiarity. But we had a committee of some 25 experts on all kinds of environmental pollutants, including water, waste, and whatnot, odors, and we found that many of the variables that we have been identifying in our noise research really apply almost generally to all of these other environmental stressors, so that in writing this particular chapter it is in a general formulation, and some of it, of course, would not apply to noise but would to other environmental agents.

But the general characteristics of the environmental agents that we identified as important in knowing about and controlling in any studies of dose-response relationships are one of quality or composition of the agent. With respect to noise, this would be the spectrum shape pretty much in the energies in the various Hertz.

In the case of odors, there are chemical quality radients that you would have. Then there is the intensity of each single exposure of an agent, and we have various measures in the case of noise from dB(A), EPNdB, and so forth.

Then, there is the time history and duration of each exposure, and this is the number of exposures per unit of time, day and night, seasonally, year-in-year-out, which should be understood to get the varying effects on man. These are somewhat peculiar. There is the source-producing exposure. Now, in noise you have many sources—from aircraft to automobiles to diesel trucks, sirens, the hotrods. And the nature of the source itself, besides the physical characteristics that it produces, should be recognized and controlled in any study of human response.

Then, we have a factor which we call "indirect stimulation of agents." This is the fact that when we are studying noise in the real human environment, people are in a given locality varying periods of time. The wife may be home all day long; the husband home primarily in the evenings during the week, on weekends and holidays, and so forth. But there is a social stimulation from the conversations of the wife. The husband comes home and she says, "God, did I get it today."

And if you question the husband, he incorporates some of that —what I call an "indirect stimulation"—into his own reaction and perception of the situation.

The second major chain of events in the theoretical systems approach is the perception of the stimulus, and I think others have pointed out here the fact that it exists and can be measured —and I think Henning pointed this out—is no indication as to whether the individual even is aware of it at the conscious level—he may be reacting to it unconsciously physiologically—and there are a whole series of variables that we have identified that can go to explain variability in perception. These are sensitivity differences in individuals in their sensory mechanisms alone.

The living activity context—what they are trying to do; what makes it an unwanted noise; whether they are trying to sleep or whether they are trying to talk, or just horse around with one of the kids would make a considerable difference.

The recognition of the content of the stimulus is extremely important, and a case I like to cite is the mother who is attuned to the crying child, whereas others couldn't care less and be completely unaware of this fairly low intrusion over the ambient that is meaningful to one and not meaningful to the other.

There, there are the attitudes towards the sources producing the stimulus—and this is something that we have done most of our work in the aircraft field. It includes such things as fear, as feeling that the source is misfeasant, that it could avoid and modify the intrusive air pollutant, noise pollutant, but it doesn't do so for a variety of insufficient reasons, and therefore there is greater perception even. I am not talking now of annoyance, which is another dimension. But they will be more aware of and ready to listen to and respond to, if they have these other built in attitudes towards the source.

In the case of occupational noise, for example, you can turn it off, Henning, because it is a standard signal. Its meaning is clear and invariant, and therefore you have no reason to receive it, and you actually can turn it off physiologically. We know what the mechanisms are actually for this event.

Then there is the interference with living activities and sleep; rest and relaxation have been identified as one of the most important activities that people react to. The mental and physical activities, including reading and task performance and recreational activities; the various communication activities, including listening and conversing. And then I have a factor in here which may not be so important to noise which is living in a clean, litter-free locality. It is the general context of the esthetics of the community in which one lives which predisposes one to be receptive or nonreceptive, perceptive or nonperceptive of even an acoustic stimulus.

Then, how does the organism, after he perceives this acoustic stimulus react to it? You have your physiological responses and I won't go into that. I think it has been fairly well covered by others before me; and you have your psychological responses of annoyance or nonannoyance, and this can be scaled from zero to any number of cutting points that you want to establish. And some of the most important variables affecting this are the belief in the importance of the primary functions of the noise source. For example, when people talk about a hotrod, by definition almost they are saying that this is a useless activity. He doesn't have to gun his engine and remove his muffler to start with, so that he isn't doing anything of any value as opposed to perhaps an aircraft noise where they would recognize that aircraft transportation is important.

Then the question is: How is it being operated? Is it being operated in such a fashion that the operators are taking every possible precaution to protect the rights and respect the rights of people in the real environment? This is the misfeasance characteristic which I mentioned before.

Belief that the noise affects general health, whether or not it is a fact, is an extremely important variable. Its on the basis of the belief that the person then will act with respect to whether or not he is annoyed with the source.

The threat to personal safety in the case of aircraft and fear of crashes is exceptionally important although in the case of traffic noises it appears also to be important because the speed and the number of passages of automobiles can be perceived as being threat to people at particular crossings, especially to children who aren't aware of the hazards.

Then, how does a person respond once he is annoyed? And there are a variety of direct and indirect indicators which are mentioned here. Personal communication is one. He may complain in a variety of ways. But this has been found to be a very poor indicator of the underlying feelings of distress and annoyance, and there are a variety of factors that influence whether or not a person ever expresses his feelings.

Then there are indirect indicators, like population mobility; whether or not he feels like moving and actually can and does move away from a stress situation. And this was mentioned by Dr. Dougherty as a self-selecting kind of a factor that you have to be careful about studying populations at a given slice of time in a survey.

Well, I won't go into some of the other actions, but I will leave this with you for your information.

Now, what are some of the things that we know? The recent Heathrow II study was a study of over 4,000 people in a 15-mile circle around Heathrow Airport. That included a very big chunk of the whole metropolitan London population, so that although we don't have the physical correlants with respect to other kinds of noise exposure; we do have them with respect to aircraft noise exposure.

The kinds of spontaneous comments that I will present in the record are indicative of the context of which noise is perceived in relation to kinds of noises and other kinds of stress.

One of the first questions in the community surveys which Dr. McKennell in England and I have been conducting in this country, and Dr. Sorensen in Sweden is a series of open-ended questions, where no indication is given of what the inquiry is about. It is described as a general study of communities, of how people feel about living in different parts of the country or countries, of likes and dislikes about where they live.

And one of the first questions is: What are some of the things you don't like about living around here? And in the Heathrow study there was great stability between the first and second studies of 1961 and 1967 incidentally, and I will cite only the 1967 findings.

Noisy aircraft was spontaneously mentioned by 11 percent of the population; traffic noise by half as much, by 6 percent; other noises—mostly people noises and commercial noises, by 6 percent. The cumulative total of 23 percent was the response of noise being disliked around here on a voluntary comment basis. Over one-third of the population are what we call "imperturbables." They dislike nothing; everything is just fine. So if you related to those that had dislikes, it represents about a third of the population that verbalizes one or more dislikes.

Now, poor public facilities was 19 percent. It was the largest single item, although the cumulative noise exceeds it.

Traffic too much—which may be congestion or it may be partly noise, but there was no way of decoding this as other than a general comment—14 percent of the population.

The second question that was asked: If you could just change one thing in your environment, which would you choose? Aircraft noise was mentioned by 6 percent; traffic by 3 percent; other noises by 3 percent; a cumulative total of 12 percent of the population mentioned noise as the one thing they would like to change most. And again converting this to remove the one-third who are "imperturbables" that is about one-fifth of those that had things they wanted to change. Public facilities—out of 17 percent response, traffic, 11 percent, in general.

When asked to describe the overall noise rating of their area from "very quiet" to "very noisy," on a 4-point scale, one-third said it was noisy, and two-thirds said it was quiet, which indicates that in general they still feel they are living in fairly quiet environments in this big 15-mile circumference around the airport.

Nevertheless, when asked—this is in general—but when asked a different way: Does noise ever bother or annoy or disturb you in any way at all, which is a different parameter, 59 percent said yes; and 27 percent said often; and the other 32 percent only occasionally or hardly ever.

When asked: Did you ever feel like moving from this area, as opposed to that 12 percent figure—I don't know where that comes from because I understood that the mobility in the United States is about 20 percent or so move every year or so anyway—45 percent in the London survey said they felt like moving from where they were. They were a little dissatisfied or a lot dissatified, and noise was given by 17 percent; climate incidentally in London by 29 percent; and smoke and dirt, which would be of interest to EPA, by only 12 percent—less than noise; and there were a whole series of other smaller reasons people had—dislike of the house, the neighbors, and so forth.

Now, when asked about the kinds of noise they heard, 94 percent reported hearing the aircraft, perceiving it; 38 percent reported that it bothered them very much or moderately; and 62 percent, a little or not at all, or not even hearing it—6 percent didn't even hear it.

Now, American results are not really comparable to the Heathrow study, so that although I have them I won't cite them in this context because the American survey design was specifically to get high impact aircraft exposure areas, so that you would expect a much higher annoyance response. And I will report where we control for level of noise exposure comparability between British and American experience.

But on a traffic noise, in the Heathrow study, 82 percent reported hearing traffic noise. This was voluntary. You know, what kinds of noise did you hear? They mentioned aircraft, or traffic, or people, or anything else that came to their mind.

In the United States it was 86 percent in the TRACOR study which is just about the same, not statistically different, I would say. Twenty-nine percent of the British reported more than a little annoyance with traffic noise. And the comparable figure in TRACOR was 36 percent, a little bit higher. And I really didn't calculate whether this was statistically significant. It might be a little.

Now, as to some of the major effects of aircraft noises are reported voluntarily by people in both the London and the TRACOR studdies in the United States, startle is reported by 24 percent of the population, being awakened from sleep by about 36 percent, listening to radio or TV by 47 percent, and surprisingly 58 percent report interference with the picture—the flutter—with watching the TV. I understood that most of the more modern sets have built-in devices for—Milt says no. Okay.

Conversation reported by 37 percent, as being an activity that is interfered with.

Now, as far as annoyance is concerned, 13 percent report that startle annoys very much or moderatly; that being awakened by

19 percent, which is over half of those who report the occurrence of being awakened, that listening to radio and TV, 32 percent report annoyance more than a little; and 26 percent report this kind of annoyance for watching TV.

Now, I would like to now turn to this new data, and I will leave this report—a special report of recent British and American noise surveys with you, which defines the terms and gives you the curves of control for the level of exposure—and I use the CNR criterion—and two other independent human variables: fear and misfeasance; and annoyance as the dependent variable.

I will just cite some of the overall relationships that we have found in a joint British study.

Now, if you take, as a floor, those who have no fear at all of aircraft being a hazard to them, and no feeling of misfeasance at all—they feel that the operators of the source, of the aircraft, are doing the maximum that they know how to moderate their effects on people—you come out with a curve that rises from 4 percent feeling highly annoyed at less than 96 CNR to about 20 percent at 105 or greater CNR levels.

If you take the opposite extreme—those people who have very high fear, and who have a feeling that the aircraft operators are highly misfeasant, that they could do much to reduce what they are now exposing people to, you go from something like 50 percent with high annoyance to 90 percent high annoyance at 115—well, you reach 90 percent at about 110 CNR. So you see how important it is, in studying a population—you can get clusters of these two extreme groups, and you can come out with a statistical average and you can describe its variance and all kinds of other statistical manipulations but you can get very distorted pictures of how people react unless you control carefully for just at least these two, and ideally for many other variables. But with these three independent variables, we probably explain about 60 to 70 percent of the human variants.

In a study which Dr. Brémond did in France—a copy of which I don't have but I can make available also—on sonic booms—to the committee—he explained over 90 percent of the human variants by using inputs of both the physical parameters and what I call "predispositional factors" that make for hostility or acceptability of a given stressor.

Dr. MEYER. We would like that for the record, please.

Dr. BORSKY. Okay.

Now, to go to the last item—I don't know how much time I have taken—

Dr. MEYER. You have all of the time you need, Paul.

Dr. BORSKY. Okay. To go to the last item as to what are the gaps, or what needs to be done—and there are quite a number of them—in the field of the physical stimulus, I would say that the greatest gap is in how one integrates numbers of individual exposures over time. We have various measures—NEF, CNR, NNI—and they make certain assumptions, but they are not really based upon hard evidence of studies where populations in either controlled field experiments have varying stimuli, and their responses are then independently related to see the effects of these variables. And I think that this recent whole press rhubarb about NEF is indicative of the need for some hard scientific data on this area.

Now, I will come to a description of our laboratory in a moment. I think that some of this might even be done in laboratory environments which are far less costly and time-consuming, and probably better in quality in terms of control over the variables.

I think that what we really need is a flow back and forth between field studies and laboratory studies, where good hypotheses and theories are developed perhaps in laboratories, taken out into the real environment to see if it works, and then when it doesn't, as they usually don't, you come back to your laboratory with additional variables that you try to tease out until you get your best kind of set of explanations.

Now, the social surveys have advantages and disadvantages. These are outlined in one of the papers I am leaving with you. The real laboratory's great advantage is its ability to control in a better way the variables you are trying to study. We have built at Columbia, with NASA university-funding support, a real environment laboratory, which is a triple-wall IAC chamber with an ambient level of about 14 dB(A). We recently remeasured it, and actually here you have stimular noises and it is kind of frightening to be in there with everything turned off including the ventilating systems.

It is actually an environmental chamber we control for temperature and humidity as well as the sound sources. And we are using a four-speaker sound system which permits us to get tremendous realism in the way of environmental noises. We can simulate movement overhead from any quadrant of the room to any other quadrant, or alongside the room in any of the dimensions. And the room looks like a living-room. It smells like a new living-room; new furniture, carpeting, couches, chairs, a color TV set. And we have a series of experiments that we are hoping to perform in the next year or two to attempt to tease out the relationships between the physical variables and the human response variables.

The subjects will be prescreened by a community survey where they will be studied in their real environments, and we will secure their unbiased real responses, of which noise is in context to other environmental factors. We will then attempt to categorize people into high, medium, low, or any number of groups of predispositional groups with respect to noise. And then knowing this, inviting them into our laboratory under controlled environmental stimulation, getting them to record the extent to which a real activity, watching a color TV program—and we have the capabilities of presenting a standard program, so we don't get variability in content—and asking them to report periodically the extent to which their listening and watching was interfered with, the perceptual aspects; and the extent to which this interference resulted in annoyance from a scale of zero to 4 or whatever we come out with—that is what we are using right now.

I think that a series of such carefully controlled studies will give us more hard data on what the thresholds of acceptability are for political decisionmaking, and these are political decisions. I would like to emphasize this.

The number of people, the extent of the population that you, as a political decision, decide you want to protect—you are not going to protect 100 percent—certainly the neurotics, whatever percentage they are in the population, will be annoyed by many things including noise; even noise that they think they hear, which may not even be physically measurable.

So that the percentage of population you want to protect, and the level of protection in terms of whether you will say that people must absorb a little annoyance but not moderate or high annoyance—these are political decisions. But we can generate the kind of information from our field and laboratory approaches that will indicate these curves of percents of populations responding in terms of interference or annoyance or any other way you want, and in terms of the physical parameters to which they have been exposed. Then I think you can really develop criteria and regulations, knowing with some certainty after replication, you know, in other laboratories, what you are actually protecting and whom you are protecting.

I guess that is about it. Thank you very much.

Dr. **MEYER**. Well, thank you, Paul, for giving us a capsulization of your recent experiences and the information as to what your views are.

(The documents submitted by Dr. Borsky follow in their entirety.)

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By

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October 18, 1971

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I. Introduction - There is general awareness today that noise pollution is one of the important environmental problems and that aircraft noise is one of the most significant sources of unwanted noise. Some of the key unanswered questions, however, are the extent to which people are actually annoyed by present aircraft noise exposures and what levels they consider as generally acceptable. To provide FAA and DOT administrators with some of the best available information on these questions, a special comparative analysis was undertaken of recent British and American community noise surveys. This preliminary report will describe briefly the two studies, the problems of comparability and present a summary of data that can be used in the political decision making to establish noise criteria and rule making on aircraft noise exposures.

II. Description of Surveys - A. General Factors - It should be understood at the outset, that social survey data, which are described below, have both advantages and limitations. They are studies of cross-sections of populations exposed to actual noise experiences and reporting their reactions to both noise and other environmental stresses in the total context of a real environment. Such surveys are best designed to measure how particular populations at specific locations feel at the time of a survey. Generalizations required for overall policy and planning may use such data, but it should be recognized that the average numbers calculated from such surveys are based on a limited number of geographic areas (four in this report), and that the estimates of noise exposure do not have the accuracy of a controlled laboratory. In the real environment actual noise exposures vary greatly and survey estimation is a gross procedure. Nevertheless, the following data are believed to be the best available and may be used as guides in assessing human response to airplane noise exposures.

The TRACOR survey was conducted in the United States for NASA in two phases. Phase 1 interviews were completed in 1967 at four airports, while phase 2 was completed in 1969 at the Boston, JFK-New York and Miami International Airports. For a number of technical reasons, after discussions with TRACOR personnel, it was decided to use only the 2912 interviews from phase 2 in this special analysis.

The second London Heathrow airport survey was conducted in 1967 and included 4,699 usable interviews. As the following table indicates, the American study concentrated on populations residing in high noise exposure environments, while the

British design selected most of its interviews in areas of lower noise exposures. If the data from the two surveys could be tabulated on a comparable basis, the combination of the results would provide a balanced set of more observations than have ever been available for analysis.

Table 1

Number of Interviews by Noise Exposure

| CNR | British | American | Total |
|---|---|---|---|
| <96 | 3221 | 146 | 3367 |
| 96-99 | 419 | 195 | 614 |
| 100-104 | 539 | 589 | 1128 |
| 105-109 | 261 | 455 | 716 |
| 110-114 | 105 | 613 | 718 |
| 115+ | 102 | 914 | 1016 |
| Total | 4647 | 2912 | 7559 |

## B. Definitions and Problems of Comparability

The specific questions asked and their order in the questionnaire in the two surveys, unfortunately, were somewhat different and, therefore, it is not possible to establish exact comparability between the two sets of data. Dr. A. C. McKennell and Philip Prescott of the University of Southampton and Harold Patterson of TRACOR helped design and analyze detailed cross-tabulations of answers to different questions dealing with common human response variables and conceptual consistency was finally achieved to a great extent for the major attitudinal and psychological response scales. As a result, it is now technically possible to compare and combine the two sets of survey data and for the first time have a single analytical model based on responses from populations of more than one nation.

The analytical model contains three independent variables (noise exposure, feelings of fear and misfeasance) and annoyance as the dependent response. The full model contains 162 response groups, as shown in table 2 and will be reported in detail in a technical paper now in preparation. In this report, only selected combinations of the variables will be presented to show the ranges in annoyance responses.

Table 2

Analytical Model of Annoyance Response

| 6 CNR Noise Exposures | X | 3 Fear Intensities | X | 3 Misfeasance Intensities | X | 3 Annoyance Intensities | = 162 Groups |
|---|---|---|---|---|---|---|---|
| <96 | | None | | None | | None | |
| 96-99 | | Moderate | | Moderate | | Moderate | |
| 100-104 | | High | | High | | High | |
| 105-109 | | | | | | | |
| 110-114 | | | | | | | |
| 115+ | | | | | | | |

Annoyance is defined as a feeling of displeasure associated with the unwanted noise believed to be adversely affecting the individual. "No annoyance" literally means that no activity interference was reported by a person as annoying. In the British study, 6 items were used to develop a 6-point scale of annoyance, i.e.,

Score one point for each of the following:

1. General question - aircraft is annoying
2. Airplanes wake up - very or moderately annoyed
3. Airplanes interfere with conversation - very or moderately annoyed
4. Airplanes interfere with listening to TV or radio - very or moderately annoyed
5. Airplanes make house vibrate - very, moderately or a little annoying
6. Other effects - very, moderately or a little annoying

"High annoyance" was defined as a score of 4 or more, and generally included more than a little annoyance with at least 3 activities and an answer to the overall question that aircraft noise bothers very much. "Moderate annoyance" includes persons with scale scores of 1-3. When the term "Some Annoyance" is used in this report, it includes both High and Moderate Annoyance responses.

In the American study, 9 items, including the British six, were included in the annoyance scale. Each item could be scored in intensity of reported annoyance from 1-5, where 1 equalled none, and 5 equalled very much. The maximum annoyance score was 45; 1-9 = no annoyance, 10-20 = moderate, and 21+ = high annoyance.

The detailed separate British and American annoyance responses will not be shown in this summary report. It should be noted, however, that the percentage of persons with "high annoyance" responses in both studies, was almost identical in the analytical model. The British respondents, however, consistently more often reported a little or moderate annoyance. Consequently, the combined data, increase the American percentages of persons reporting moderate annoyance.

With respect to the independent variables, their definitions are as follows:

1. CNR - Composite Noise Rating - A composite index, where the numbers of exposures and "perceived loudness" of different aircraft are combined separately during daytime and night time hours, such that 10 daytime flights are the equivalent of one night time exposure, and a doubling of daytime flights increases the CNR index by units. The actual formula is:

$$CNR = 10 \operatorname{Log}_{10} 10 \frac{L_{pn}}{10} + 10 \operatorname{Log}_{10} N - 12$$

2. Fear - A belief that the aircraft producing the noise poses a threat to one's safety. The noise connotes an approaching plane and fear is the belief that it may crash into the place where the person is located. As the noise content indicates

a safe over-flight or departure, the tension associated with the fear is reduced.

3. Misfeasance - A belief that the aircraft operators have the knowledge and ability to modify the noise produced by the airplanes but choose not to do so for a variety of reasons believed to be insufficient. The achievement of comparability in this variable was most difficult but after careful comparative analysis of responses, it is believed that the two sets of data now generally measure the same factor.

## III. Results

### A. Overall Relationships

Figure 1 compares the overall "high annoyance" responses for three selected psychological pre-dispositional groups of people living under the same noise exposures. Figure 2 presents a similar comparison but the annoyance response is for total or "some annoyance" which includes high and moderate annoyance.

Those persons included in the solid line, lower curve, represent the group most favorably predisposed to accommodate the noise; they express no fear, and feel the aircraft operators are doing all they can to minimize the noise. Thus, this curve probably represents the lower floor of annoyance responses. It should be noted that while only about 20% of this most favorable group express "high annoyance" at even very intense noise exposures, over half indicate "some annoyance" at exposures of over 100 CNR.

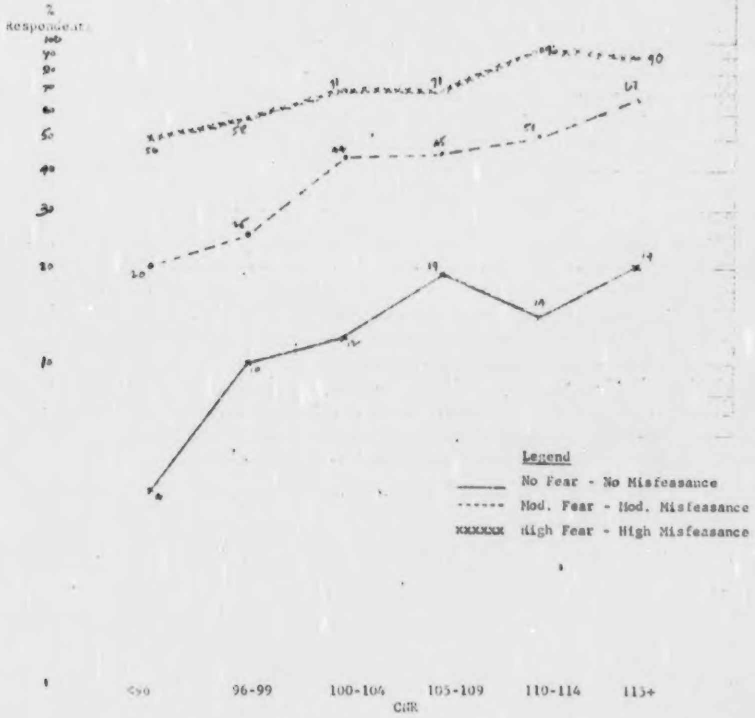
The top line in both figures represent the opposite extreme, or the most psychologically hostile group. They can be considered to represent the ceiling in a series of annoyance curves. They have feelings of high fear and high misfeasance. Over half of them report "high annoyance" at even low noise exposure levels and almost all indicate "some annoyance" at all noise exposures. The particular combination of these predispositional groups that one happens to select in a sample of respondents determines the average calculated annoyance response for that community.

In using the two extreme curves for planning purposes, one assumes that the worst possible conditions or the most ideal conditions will exist. Neither assumption is probably realistic. That is why the middle curves are included in the figures. They assume that there will always be residual moderate fear and moderate feelings of misfeasance even after efforts have been made by the operators to reduce the environmental impact of their operations.

Figure 1

by Reported High Annoyance with Aircraft Noise
CNR - Fear and Misfeasance

Reproduced from best available copy.

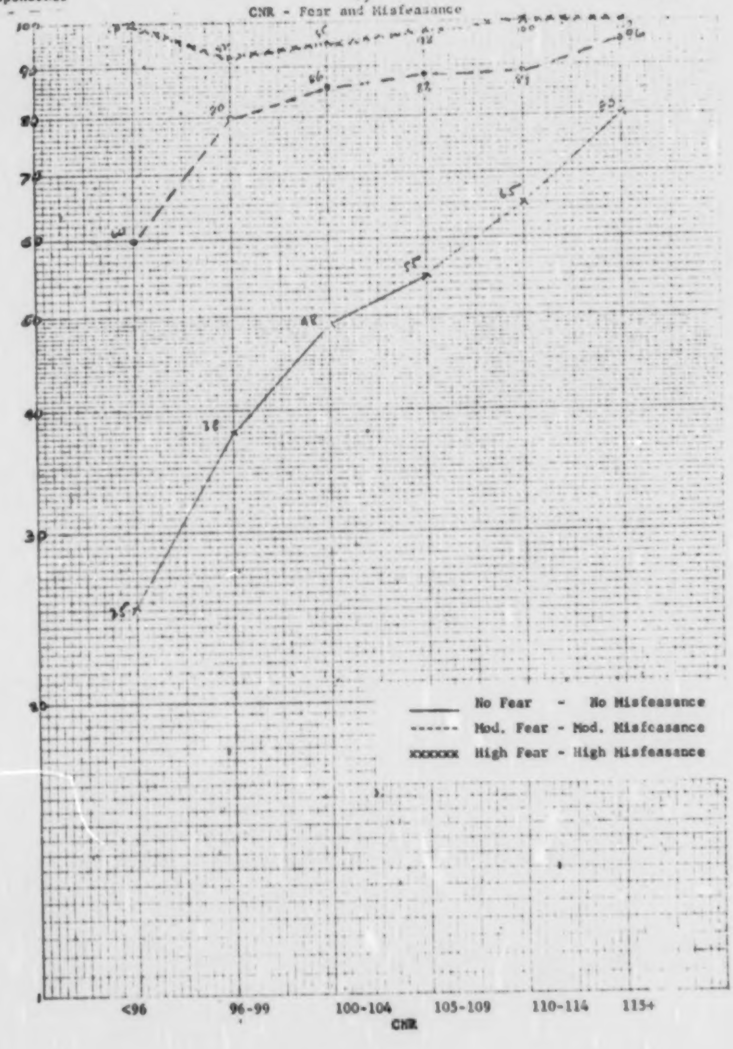


% Respondents

by

CNR - Fear and Misfeasance

Figure 2



## General Framework of Perception and Response to Environmental Agents

Subsequent sections of this report will present detailed discussions of the different methodologies available for measuring and evaluating the effects on individuals and groups of environmental pollutants. This section presents an overview of some of the major variables and their complex interactions believed to affect primarily annoyance and other human response to these environmental agents. It also discusses some general methodological problems involved in measuring these variables as well as suggested criteria for the utilization of different methods.

### I Environmental agents

The initial variable stimulating annoyance and other responses is the unwanted external environmental agent. As indicated, the agents of principal concern are odors, noise, vibrations, solid wastes, urban crowding, water pollutants, food pollutants, food processing methods and air pollutants other than odors. Each of these unwanted agents have special characteristics which must be separately measured in order to describe the different environments in which people live, and to understand the related differences in annoyance responses.

For example, in studying the effects of most agents destinctions should be made in at least the following:

a) The quality or composition of the agent.
In the case of odors this has been defined in terms of a pleasantness quality scale which is related to the chemical quality of the odor. In evaluation of noise exposures this is described in terms of the spectral shape of the complex noise.

b) The intensity of each exposure of the agent

In odors, this is measured in vapor pressure or odorant expressed in ppm. In noise, this is calculated by assigning different weights to the energy in different octave bands.

c) The time history or duration of each exposure

This describes when, i.e. during the day or night, weekday or weekend, season etc., as well as how long each occurrence persists.

d) Frequency of occurrence

This indicates how many exposures occur in a given unit of time.

e) The source producing the exposure

This refers to the particular source of the agent. Human responses may vary for the same agent for different sources. For example, the noise from people or the factory where one works may be viewed quite differently than that from an airplane or a nearby highway.

f) Indirect stimulation of agents

Although a person may or may not be directly exposed to an agent, he may receive an indirect stimulation from other sources. The indirect source may be a conversation with members of the family or other persons, the mass communication media reporting on exposures and their "effects", or contacts with groups concerned about the effects of the agent.

## II Perception of Stimulus from environmental agent

The process of human response begins with the perception of the stimulus. The fact that the stimulus can be measured objectively by an instrument does not necessarily mean it is actually perceived by all persons exposed to it. At least four factors may influence whether or not and how a stimulus is perceived.

### a) Variability in sensitivity

This refers to differential capabilities of individuals or groupes of people to perceive the stimulus and generally is related to physiological differences in their sensory systems. Persons with chronic bronchites are particularly sensitive to air pollution.

### b) Living activity contexts

What one is doing or wants to do at the time of exposure may affect whether and how the stimulus is perceived. For example, whether one is asleep, reading or playing with his children may differentially influence perception.

### c) Recognition and content of stimulus

The relevance and meaning of the stimulus is another possible modifier of perception. The cry of a child may be more readily perceived by his mother than by a stranger especially if the intensity of the sound is not great.

### d) Attitudes toward sources producing stimulus

Whether or not a person has hostile or friendly feelings toward the source of the stimulus may influence his his pre-disposition to perceive an exposure of the stimulus. This factor is probably more important in evaluating annoyance but it may also play a part in being aware of the stimulus.

## III Human response

### A. Psychological annoyance

With the knowledge of the character of the unwanted environmental agent and the way it is perceived by a person, the following psycho-social variables may modify the feelings of annoyance:

#### Interference with living activities

Some of the more frequently reported activities which are disturbed by environmental agents are:

a) sleep, rest and relaxation
b) mental and physical activities, including reading and task performance and recreational activities
c) communication, including listening and conversing
d) tasting and smelling
e) living in a clean litter free locality with the desired space and population density.

The type and extent to which a desired living activity is made more difficult or impossible by an intruding environmental agent will usually be directly related to annoyance.

#### Attitudes toward source of agent

It has been stated that this variable may modify perception of the agent but it is even more important in determining feelings of annoyance. In general, attitudes may be described as hostile or friendly with respect to the source producing the agent. Hostile attitudes generally increase perception and annoyance while favorable friendly ones enhance unawareness and acceptance of the agent without annoyance. Some of the more important negative intervening attitudes are:

a) Belief in the lack of importance of the primary functions of the source. A missing or defective muffler on a car produces noise and is generally considered non-productive. Such beliefs usually predispose more annoyance.

b] Belief in the misfeasance of the source. This may be defined as the belief that the source has the knowledge and ability to modify its activity to reduce the unwanted agent, but chooses not to do so for a variety of insufficient reasons. When one believes source is misfeasant a person is generally predisposed to be more annoyed.

c] Belief that the agent affects general health. When one believes that the presence of the agent has a harmful effect on general health, there is usually greater annoyance.

d] Belief in the threat to personal safety. The fear that an agent or the source producing the agent poses a threat to one's safety generally increases the predisposition for greater annoyance. Examples are the fear of a crash from planes flying overhead, the danger of accidents at a busy intersection, the harm from toxic agents etc.

## Number and degree of perceived disliked environmental agents

If a person has more than one disliked environmental agent in his environment, he may transpose annoyance with some agents to an exposure of another agent. Likewise if some agents are extremely disliked, they may mask annoyance with other agents. Consequently, the context of all environmental agents must be considered in evaluating annoyance to any one agent.

## Inability to reduce unwanted agents by own independent efforts

If a person feels unable to control or reduce the unwanted agent by his own efforts he may be more annoyed. If a person feels entrapped in his dwelling, i.e. he cannot move and find a suitable dwelling outside the infludnce of the agent, he may be more displeased with the exposure of the agent.

## Previous exposure to environmental stressors

While the influence of past experiences with environmental agents are not clearly understood they should be considered

Other personal variables

There are many other possibly related variables that could be considered, such as, age, sex, social class, family composition, length of residence, group affiliation and involvement, education, occupation and economic or other relationships to the source of an agent.

B. Physiological responses

The physiological responses to annoyance stimuli are by themselves not necessarily valid indicators of annoyance. On the other hand a number of physiological measures may supply the investigator with supporting evidence of:

a) the strength and time course of the response of the organism

b) clues to the direction of long term effects

In addition, when the relations between the physiological responses and feelings of annoyance are established, measures of the physiological response can be used to predict aspects of possible feelings of annoyance. It is also to be noted that various physiological phenomena may: 1) in and of themselves engender feelings of annoyance; and 2) if sufficiently prolonged and repeated possibly lead to ill-health

## IV Behavior expressions of annoyance

### a) Direct indicators

Whether or not a feeling of annoyance is ever expressed to someone else or whether it remains a silent psychological emotion depends on a number of intervening variables. It should be noted that expressions may be voluntary or elicited and that different factors facilitate and impede such expressions. Some of the forms of expressions are:

1. Personal communication of the feelings with the source or the authorities. This could be verbal or written
2. Support of Group Action. If asked to sign a petition, attend a meeting or participate in some other group action designed to reduce or modify the source, a person may do so.
3. Help organize group action. A more difficult expression, involving more effort and activity is to assist in the creating of organized opposition to the source.
4. Legal action. The decision to resort to legal action to modify or eliminate the source or even obtain compensatory damages is an extreme form of annoyance expression.

### b) Indirect indicators of annoyance

In addition to direct reports and other actions by persons expressing their feelings of annoyance, some of their actions may also indicate the extent of annoyance. Some of these less direct indicators are:

#### Population mobility

These include residential mobility, recreational choices and selection of work location. Moving away from the influence of the agent may be inferred to be due to annoyance if proper care is exercised to control for other causes.

### Economic

Such measures may cover expenditures for control of the agents impact, medical expenditures and trends in property values.

### 2.423 Consumption and behavioral preferences

It is probable that a number of patterns or changes in patterns of consumption or other behavior are partially or entirely due to annoyance. These may be due either to (1) personal experiences producing annoyance in some portion of the population, or (2) to annoyance with situations learned from others, or from mass communication sources. Examples of the first type would be: increasing use of bottled spring water or other beverages cuased by dislike of the odor of flavor of the available public water supply: unusual use of certain drugs e.g., tranquilizers, sleeping pills, alcohol, in areas with high levels of noise nuisance: Closing of windows in warm weather to exclude noise or odors: avoidance of certain recrational areas due to pollution. Examples of the second type would be: Local cleanup and recycling efforts: changes in food sales because of fear of dangerous content even where to items in question are stated to have acceptable levels of contaminants: purchase of biodegradable or low-phosphate detergents because of annoyance from eutrophication of waterways.

### 2.424 Trends in group organizations

Several organization trends may reflect annoyance with environmental stresses. These include increasing numbers of voluntary associations and governmental agencies concerned with environmental problems, or a broadening of the goals of these organizations from those present at their founding. Both the increase in numbers of members and the wider scope of action of these groups may bear a close relationship to annoyance present in the community.

### 2.425 Governmental and legal actions

A variety of governmental actions are applicable to the control of man's environmental stresses and nuisance. These include the making of laws, ordinances and regulations; the enforcement of such legislation through inspection for compliance, and the follow-up of complaints of non-compliance; and the prosecution of violation where required. All of these actions are matters of public record, and are therefore available. The number, character and quality of these actions can be determined. It is probable that such actions reflect public annoyance to a considerable extent, but certainly this is only one of several factors causing governmental action, and not always of great importance.

## 2.5 The problem of the dose-response relationship

In the preceding sections, an attempt was made to outline in a simplified manner the path between the emitting source *via* the individual's perception of the agent, and *via* the feeling of annoyance, as defined above, and eventually to the overt expression of annoyance. A psychologically defined dose-response relationship should in fact be the relation between the *perceived* agent and the consciously felt annoyance. In order to accomplish this objective, it is, therefore, essential that not only the physical measure of the agent be included as the dose, but the psycho-social variables that affect perception be integrated in the estimate of perceived exposure. Then this variable can be related to annoyance and other responses. In practice, this prodeedure has not always been possible, and the physical measure by itself has been related to expressed annoyance. The correlation between these two variables in the relationship may be very weak, however, due to the variance caused by the other omitted factors. As was suggested in the preceding sections many intervening factors are likely to act between emission and perception as well as between experienced annoyance and reported annoyance. If these factors could be accounted for, or controlled, or at least better understood, the variance of prediction would be considerably reduced. This has actually been partially done in recent American and British noise studies. Methodology has to concern itself with all the relevant factors all along the line; it is premature to suggest where methodological improvement may be most successful. Certainly the measuring of the experienced annoyance, however, is a weak point that has to be considerably improved.

## ADDITIONAL STATEMENT BY DR. BORSKY

Dr. **Meyer**. Before I ask a question I will start off with Don Eldredge and ask if he has any questions or comments.

Dr. **Eldredge**. Thank you. I think your numbers are very important, and certainly the kinds of things that we need to know.

There is one feature that I wonder if any of your formal part of your study or any of your informal feelings about this could answer the question. I will put it this way: Transportation noise seems to be a particular problem because it can go to an environment which someone might already have established, and one might, in a sense, then—this represents an invasion of privacy or an abridgment of your right to decide how quiet, you want your home, for example. And what I would like to know is whether you detected very much in the attitudes of people that they were having these rights abridged or their privacy was being invaded.

Dr. **Borsky**. Very much so. This is central. The noise is unwanted because it interferes with their expectations and desires of the kind of quiet environment that they want to perform certain activities, and this is an exterior intrusive signal that they aren't controlling, and therefore this generates a great deal of hostility.

Dr. **Eldredge**. And then I had another question as to where you sort of thought people stood in this overall frame of reference. You suggested that it is difficult to conceive of controlling transportation noise to the extent that it would never offend anyone. But then it also, I think, seems difficult to assume that you would control it so that it only offened 49 percent of the people. And then you bring out the idea that there are classes of people—they may be really only a relatively small percentage of an exposed population—something like 10 percent—who, for example, both fear and claim malfeasance or misfeasance. How much weight should one give to their opinion, and what do you detect in people as to—that is other people—what do they think of these people who are maybe a little bit edgy about the noise, or do they think of them as complainers, or do they think they have rights that should be considered?

Dr. **Borsky**. Well, I didn't make this statement, but if you just take the noise parameter—CNR or whatever you want to use—you can get a correlation of about .5 with annoyance intensity. About 25 percent of the variance could be explained in a rational way by the fact that you do get this rising curve with more intense annoyance with a more intense exposure. And the feelings of misfeasance and fear are also intercorrelated with the intensity of the acoustic experience. So that where you have sort of a neurotic or a very minority kind of hypersensitive population, the rest of the community obviously would sort of feel, well, that is a personal problem, not really a community problem.

But where you get up into levels of CNR of 100 or more, the majority of the people feel this way, even those who are what we call predisposed—they report some annoyance although not high annoyance. And if you take moderate cuts, as I have in the paper there—moderate fear, moderate misfeasance—you get an in between cut in terms of percentage of people.

So that generally—in fact, we have used questions, as you probably know—and I don't know whether you were referring to this—we used projective type questions. We asked people: How do you think others feel about this? And, in general, people feel that others support their feelings and even more so. In other words, they are strong and resistant, whereas others feel more strongly that this is a pretty bad situation. So that in most cases, they feel social cohesion and supportiveness by the rest of the community.

Dr. **ELDREDGE**. So what you are really saying is if the levels were brought down to a level that didn't interfere with too many human activities, probably many of the negative attitudes would also tend to disappear.

Dr. **BORSKY**. I think you would have a double payoff—that is correct. If people could perceive improvement—behavioral—they would then change their feelings of misfeasance—I don't know about fear—and you would come down to a lower curve, even with the same levels of exposure. You would get an additional payoff in reduced annoyance if you have reduced feelings of misfeasance. And I have done such an exercise—I don't have the data right with me—but in general about 10 percent additional annoyance reduction can be secured by assuming a certain shift in misfeasance at least of one category—from high misfeasance to moderate, and from moderate to low, and not from high to none.

Dr. **ELDREDGE**. Thank you.

Dr. **WHITCOMB**. This last statement, Paul, relates to yesterday's discussion when we were, I think, trying to convince the Massachusetts Port Authority that any work on their part would be of interest to the people in East Boston—sort of a public relations demonstration that they were working on perhaps—

Dr. **BORSKY**. But it has to be real, Milt. It can't be a wordy kind of thing. It has to be reflected in a real activity change.

Dr. **WHITCOMB**. A real change.

Dr. **BORSKY**. Right.

Dr. **WHITCOMB**. A change in flight profiles, flight procedures, and so on, and a statement of what those changes were.

On your Heathrow II study, you mentioned a 15-mile zone around Heathrow. Is that in diameter or radius because it makes a difference in terms of whether rural areas are included.

Dr. **BORSKY**. Well, I am not sure about it. I think it was diameter.

Dr. **WHITCOMB**. So it was primarily urban.

Dr. **BORSKY**. Yes.

Dr. **WHITCOMB**. Okay.

Dr. **BORSKY**. Most of London.

Dr. **WHITCOMB**. So, then, in relating to the TRACOR studies—

Dr. **BORSKY**. I could check that quickly.

Dr. **WHITCOMB**. Well, I was thinking in relating it to the TRACOR studies in terms of perceived traffic noise, and so on—I think these studies were on urban populations almost solely, whereas if Heathrow is 15 in radius, that would take in quite a bit of rural area as well, which could account for the lower percentage perceiving traffic noise in Heathrow.

Dr. **BORSKY**. But the differences were pretty small.

Dr. **WHITCOMB.** Thirty-eight and—

Dr. **BORSKY.** Twenty-seven.

Dr. **WHITCOMB.**—27.

Dr. **BORSKY.** Of course, the TRACOR studies took in suburban areas—Nassau County and JFK and Miami International—you had Coral Gables and suburban—where you had fairly low ambients, too.

Dr. **WHITCOMB.** But not ever rural.

Dr. **BORSKY.** No. I don't think you really had many rural areas. The sampling rate was such anyway—you know, population proportionate to density—that you wouldn't have had much contribution from rural areas if you did include them in the Heathrow group.

Dr. **WHITCOMB.** Okay. Second question: You mentioned spontaneous reporting at the beginning of the interview of 11 percent that were perceiving or commented that they heard aircraft noise. Was that scaled out as a function of the distance, or better yet on CNR?

Dr. **BORSKY.** Not that particular. That is just an overall.

Dr. **WHITCOMB.** It would be interesting to know that there were 20 percent near and only 5 percent at a distance.

Dr. **BORSKY.** It would be very interesting. They did not do this in their report, as you may know.

Dr. **WHITCOMB.** Then, similarly for whether or not they thought they lived in a quiet neighborhood or a noisy one—

Dr. **BORSKY.** We have no control over the ambients.

Dr. **WHITCOMB.**—is something we would like to know.

Dr. **BORSKY.** There were no measures. They had some crude questions about how close you live to arterial highways or, you know, busy thoroughfares, and they are trying—their urban housing people are doing some special analyses of this. But they are going to be pretty crude, you know, in terms of ambient noise levels.

Dr. **WHITCOMB.** You commented with regard to Don's question that 25 percent of the variance could be accounted for by CNR, with regard to annoyance, I presume. What percent of the variance would you estimate could be accounted for by scaling out high to low misfeasance?

Dr. **BORSKY.** You mean just misfeasance alone?

Dr. **WHITCOMB.** Say misfeasance for a start.

Dr. **BORSKY.** I really don't—you would have to calculate it. I have some data on—

Dr. **WHITCOMB.** Intuitively do you think it would be like 25 percent; would it be more or less?

Dr. **BORSKY.** Less.

Dr. **WHITCOMB.** Less. So that it doesn't quite—

Dr. **BORSKY.** It only contributes 10 percent.

Dr. **WHITCOMB.** So the TRACOR data would have indicated that it is a more important determinate of the noise.

Dr. **BORSKY.** The TRACOR data—misfeasance was more important than noise as a single variable?

Dr. **WHITCOMB.** Yes. I thought so.

Dr. **BORSKY.** I don't know.

Dr. **Whitcomb.** I thought that there were 3 or 4 variables that were above noise exposure percentages.

Dr. **Borsky.** Well, you had very high misfeasance in the TRACOR studies, higher than in the British, so that when the data were combined on the assumption, you know, you have to—I point this out in my paper that these surveys are designed to study particular populations at a particular slice of time.

Now, we would like to generalize for them because we just have a limited number of data points to use. But we have to keep in mind that they are a limited number of data points, and the amount of extrapolation that you can make is limited, and subject to error. They are the best you have at a given point. And I think that the data which I have cited to you now, which takes intercultural and London in terms of numbers and types of operations, and the three airports that I used in the United States, which was JFK, Miami and—what was the third on the second wave?—Boston, I think—represents a pretty good spread.

Dr. **Whitcomb.** Okay, Paul, one final question, with regard to your laboratory. You mentioned you were going to test the effect of flyovers during watching TV. Are you programming any flopovers to tie this in with the Heathrow information, or are you getting a perfectly good TV set in there that won't do anything but be masked?

Dr. **Borsky.** We haven't planned it that way, but the equipment has bugs in it and we are getting flopovers that we are trying to eliminate, and I don't know whether we ought to leave them in there.

Dr. **Whitcomb.** I am simply suggesting flopovers as a—

Dr. **Borsky.** Independent—

Dr. **Whitcomb.**—variable independent of masking. My own family experience where we are under a flight path is that we are much more annoyed with flopovers than masking.

Dr. **Borsky.** There are only a limited number of things, as you know, that you can put into any one experimental design, and we are hoping not to have flopovers as a variable in our first—

Dr. **Whitcomb.** Unfortunately flopovers always occur at the most critical point in the program. (Laughter)

Dr. **Borsky.** Which is more annoying than noise then.

Dr. **Meyer.** Dr. von Gierke.

Dr. **von Gierke.** Paul, from any of the studies you discussed, can one draw any conclusions about how the attitude of people changes or has changed over the last 10 or 20 years towards noise, and how—for example, the ones which did not react at all in your London data—are those the ones who have lived the longest time in the area and have given up?

Dr. **Borsky.** No. There has been the opposite kind of indication that the people who live longer are more annoyed, that there is not this kind of adaptation that you describe over time, but there could be a variety of reasons for this. Their expectations—having lived there maybe before the operation even got under way would be different. So that there is no automatic reduction of annoyance by length of exposure; I can say that fairly categorically in all of the survey data that have been collected in all of the nations in the world.

**Dr. von Gierke.** Is there an indication that people became more sensitive to it?

**Dr. Borsky.** We haven't really designed that into our surveys, where you have to do a longitudinal study really; you have independent samples.

We were surprised at the stability between Heathrow I and II because there has been an increase in operations actually. But the analyses that they performed were very crude and did not control for enough variables, so that we cannot yet say from their data whether there was an increase or decrease in annoyance correlated to the increase in the number of operations. The gross comparisons where a lot of things can net out show no change.

**Dr. von Gierke.** You were not here yesterday when we heard several very interesting testimonies about noise levels in wilderness and wildlife areas, airplanes flying into the Grand Canyon, and so on, and where the actual noise levels are probably very low, the background noise levels are very low, too.

**Dr. Borsky.** Yes.

**Dr. von Gierke.** And I just wonder has any of the social survey studies been ever conducted in an actually quiet area where you might have only a few disturbing noises now and then to which people could react?

**Dr. Borsky.** Yes. In some of the earlier work with the Air Force, as a matter of fact, we had some very quiet rural areas, and in the Oklahoma City study we had some real rural open areas where the emergence of the intrusive signal over ambient was quite high.

Unfortunately, again, like all these multi-variant problems, we didn't have enough cases and enough controls and enough data to really be able to say whether the greater the emergence the greater the annoyance. In fact, there were no statistical differences in the data which we had, but this does not mean that there may not be.

**Dr. von Gierke.** Yes. As you indicate, these studies had always had a specific purpose or specific very strong stimuli superimposed on the quiet environment. My question was more aimed at: If you have a relatively quiet environment and then you have just some disturbing sound—motorcycles, snowmobiles, or what-not—or very occasionally an airplane—what percentage of the population would be really annoyed with this? I guess we don't know.

**Dr. Borsky.** We don't know. No.

**Dr. von Gierke.** Which leads me to a final question, I mean, more about methodology: You know Broadbent's work on the effect of noise on human behavior, and he comes somehow to the conclusion that the pursuit of happiness in itself is not an ignoble end—I guess that is how he concludes his whole chapter—and I wonder, we always talk about annoyance and the negative effects of noise. Has one ever tried to evaluate the happiness quietness can bring? I mean you—

**Dr. Borsky.** No.

**Dr. von Gierke.**—you yourself indicated, well, some people object to the esthetic offense of dirt on the streets. You cannot really say that you are annoyed by it, but somehow your esthetic sense prefers it. We prefer to sit in a nice room, although we cannot say we would be annoyed by a drab room. And why does one not try to put a value judgment on the happiness a quiet environment can bring sometimes?

Dr. **Borsky**. There are some happiness studies that Milt may be aware of. I know of them but I don't know any of the details. I can't tell you whether quietness was one of the variables included in the happiness quotients.

I know that NORC has done a series of studies trying to develop a "quality of life" index where presumably quietness would be a variable. But one of the things that came out this summer at the Karolinska meetings was the thing, I think, you are pointing to now, Henning, that we focus attention on problems, and thereby perhaps distort the context somewhat. The human being needs stimulation. It needs some ambient noise level. The absence of noise would be as harmful and vegetive to the human mechanism as intense overloading of intense noises.

So we are assuming, while we are not stating it, that we don't want absence of noise. We want it at some comfortable level of acceptability.

Dr. **von Gierke**. And one more question on methodology with respect to your own studies which you outlined. I guess we discussed this before.

Don't you see a need for something in between real field studies and your laboratory studies? I mean I would call it simulated field studies—

Dr. **Borsky**. Controlled field experiments.

Dr. **von Gierke**.—where people really live and sleep and work in the environment, and where this environment where they live might then be instrumented or exploited as a controlled laboratory situation. But still, I mean, you don't have your subject sleeping in the laboratory—

Dr. **Borsky**. No.

Dr. **von Gierke**.—and I think that is a very important—

Dr. **Borsky**. They could be. We have the facilities for them. The room could be made a bedroom.

This is another point that perhaps should be made with respect to hearing conservation and to what you are mentioning now. When the Academy developed their hearing conservation studies, it was designed in terms of studying continuous or fairly continuous noise levels for an 8-hour period really for occupational health purposes, with the assumption that the other 16 hours provided recovery time, recuperative time.

Now, with the ever-increasing technology of noises from all sources, I doubt if you can make that assumption, and there is a real need for studying the total man in a total 24-hour life cycle over some period of time, and if this is what you are referring to, I fully support this as a very important area. Of course, it has all kinds of problems.

Dr. **von Gierke**. That is exactly what I mean, but I think not only with respect to the hearing loss—

Dr. BORSKY. No.

Dr. VON GIERKE.—but with respect to—

Dr. BORSKY. You would build in all these other—

Dr. VON GIERKE.—psychological, sociological—

Dr. BORSKY.—physiological—

Dr. VON GIERKE.—to the exposure. So I mean that you would follow all case histories of families living in certain noise-exposed areas, perhaps similar to the exposures you have given in your laboratory but still follow them on a 24-hour basis.

Dr. BORSKY. We have thought, as a compromise, of trying to get recordings in the homes of our subjects, and if they cooperate where they work and—you know, I haven't really thought it through for housewives, you know, where they shop, of getting some limited number, not getting total. Now, I think—was it you, Jim, who mentioned a dosometer at one of our meetings?

Dr. BOTSFORD. Yes.

Dr. BORSKY. Now, if we did have this kind of technology where we could just hook it on a person like a radiation counter and get some kind of a cumulative exposure, it would be extremely helpful and valid in some longitudinal study that you are outlining.

I don't know. Do you have one operational?

Dr. BOTSFORD. Yes. There are at least three different designs of subject exposimeters that are operational. You can actually buy them.

Dr. BORSKY. Well, I would support such an effort.

Dr. FIDELL. I have about three or four comments more or less directly related to your testimony. Let me start off with the less and work to the more.

First, with respect to general sociological work of this sort, despite the years of work and number of surveys that have been done, going back to the 1950's, we still lack a useful measure of community response to noise: TNI, NPL, CNR—you can go on for a long time; you know them all—and they are still of precious little use in many situations. They were built for specific purposes, they are not transsituationally useful, and besides they all correlate with each other, so which one you pick is, in some cases, a matter of a difference and in some cases not. But it is just very hard to tell which one to use for what, and as new studies arise you find inapplicable and you invent your own scale. And that has been going on, I think, for too long.

The next point I wanted to make which was somewhat related to that is in some of these studies—for example, the TRACOR study—you identify—I think you are carrying the multivaried approach too far perhaps. You identify parameter after parameter. This one accounts for 10 percent of the variance; this one counts for 2.5 percent of the variance; that one counts for that much.

As Mr. Kistakowski once said, you can develop parameters up to fit an elephant. And maybe that is not what we ought to be doing. My competence is not in sociology and I don't really know what we are doing, but that sure doesn't look right.

The next thing is about assumptions. You made some comments about bad assumptions not based on hard data. That doesn't bother me so much. The worst that an inappropriate assumption will do to you is lead to a bad prediction, and the data will not bear you out, and assumptions being the coin with which conclusions are purchased, I think you will very quickly realize that the price is too high in terms of assumptions for conclusions that don't work.

As for a final quick point, I am worried about your laboratory situation with its pseudo-realism. I don't really feel that is a crucial dimension, and I think it is fraught with numerous dangers. I am afraid, for example, in attempting to come halfway between the real life and the laboratory you will forfeit the advantages of both and gain the advantages of neither. It appears to me that subjects are pretty savvy and if you take them into a little room and ask them if they are bothered by noise, they will tell you what you want to hear or what they think you want to hear, and I don't know what to do about that.

Dr. BORSKY. Well, we have previously recorded their real life experiences and responses when they had no idea they were coming to our laboratory. We know what their average noise exposure is in their real environment, and I didn't mention all of the details, but one of the signals they are going to get in the laboratory is what I call a calibration signal which is as close to their real life environment as we can get it on the average, and we are looking forward to comparing their laboratory response with their response previously recorded on a social survey.

Of course, it is not exactly comparable. One is hundreds and thousands of exposures over time, and the other is a limited number of exposures over a unit of time. But hopefully it will not be too far different.

We have just finished a series of methodological studies and one of the things which is most heartening is that by purpose the levels, in this particular study, were fairly low—about 80 dB(A), 93 PNdB—and we took people from—I don't want to mention the name—of a real community fairly heavily exposed to aircraft noise, and they said, "This is much less than we are getting in our real homes. They were making comparisons of the laboratory exposure as a real exposure to the real life home exposure, so that I am encouraged that we may come up with some real good stuff.

Dr. FIDELL. Well, I guess if you keep a careful eye on it you can at least monitor what biases and what influences that has on your data.

Dr. BORSKY. I consider this entirely experimental, an effort to develop a new methodology, and I am not trying to oversell it. I don't know what is going to happen.

Dr. BOTSFORD. Dr. von Gierke told us earlier about how well man and animals adapt to stress of noise. And I am wondering if this adaptation can be transferred.

Here is what I have in mind. Suppose in a community survey such as you have discussed, there are exposures outside the community? For example, noisy job, noisy pastime like flying or riding a motorcycle, that may shape a person's attitude or make him calloused to the noises that he gets in his community. Is that a factor in these studies that you have described?

**Dr. Borsky.** Not really. When we started out years ago, we were thinking in terms of a general noise-sensitivity variable. And there is general noise sensitivity varying from individual to individual. But its contribution with respect to annoyance is probably—is very low because the noise levels we are talking about are so relatively high. And there is selective attitudinal reaction. People will accept a high noise exposure in a work environment if they feel this is part—you know, drop forge—if it is part of the work environment, and they have the freedom to work or not to work there. And they will reject a much lower noise level in a residential environment.

In fact, I interviewed some pilots personally in the vicinity of Los Angeles Airport some years back, and found that they were the most vociferously annoyed people in the communities they live in the communities right near the airport. And I was very surprised they earned their livelihood being pilots. But their perception of the living environment as a resident and as a pilot were differentiated, and besides which their neighbors were bugging them for all of their displeasure—"You so-and-so. You are the guy that is doing it." So they are getting the social indirect stimulation as well as the noise itself directly, and they were very annoyed about the operation that they were being exposed to.

**Dr. Meyer.** Dr. von Gierke.

**Dr. von Gierke.** May I ask: Is there some indication, as we heard yesterday in one of the testimony that the more noise people are exposed to during their normal work day, the more quiet they might seek in the evening or on the weekend?

**Dr. Borsky.** I have no data on this. It might be a good hypothesis in terms of recovery time. Physiologically it might be essential, but I don't know if they are perceptive and aware of this.

**Dr. Meyer.** Dr. Borsky, this has been a very important paper.

I have a couple of questions I would like to ask, a couple being figurative. First, what percent of the population in the 15-mile determinate was involved in the survey?

**Dr. Borsky.** I don't know what the sampling rate at Heathrow was. I could check that and report it to you.

**Dr. Meyer.** I think it would be useful.

**Dr. Borskey.** But the number of people interviewed was 4,647—that was usable interviews.

**Dr. Meyer.** I see.

**Dr. Borsky.** It was a very sizable number of people.

**Dr. Meyer.** Yes.

**Dr. Borsky.** I don't know what the rate was.

**Dr. Meyer.** Another very important question which I feel we need to get in the record at this point: The statements were made, which I completely agree with, that while there is a percentage of the population that is not fearful and not bothered and doesn't feel there is any misfeasance involved, there is another percentage that I guess are mad.

**Dr. Borsky.** Pardon?

**Dr. Meyer.** That they are irritated at any event. They are fearful; there is misfeasance; and no matter what the situation is, they have a sizable reaction.

Would you venture, if you have the data or a feel for it, in a population group, what percent constitutes that lower extreme of reaction and what percentage constitutes the upper extreme of reaction?

Dr. **Borsky**. Well, we had a Gutman scale of overall satisfaction or dissatisfaction with living in an area, and it included—I don't remember now—about 20 different items. And we found that about 1 or 2 percent dislike everything, you know, which is pretty unreasonable, although we didn't have statistical controls in terms in terms of sampling theory, it is just possible that where they lived everything was just pretty horrible.

But our assumption was that this is also very often used as an index of neurotic behavior and there has been such indices used for a series of questions that you get into 1 or 2 or 3 percentage of the population.

Dr. **Meyer**. As I have indicated earlier today, some people do throw this truth by assertion business around pretty loosely. Some people have said, while studies done in England indicate that there is 10 percent of the population that is never bothered by noise, there is another 10 percent that no matter what the noise condition is they will report that they are bothered. Then we have heard also testimony that elaborates that to 15 percent and 15 percent; and then we have also heard statements that are now elaborating it up to 20 and 20 percent.

Would you like to venture, based on your impressions on this, not on a truth-by-assertion basis, but what the real situation probably is, or is this an area where we need to do a lot more study?

Dr. **Borsky**. I think you really shouldn't ask for a speculative kind of conjecture but something that should be factually determined. But I will cite this. I didn't present this in the previous testimony; I included it in the table.

I have a table here on what I call "Some annoyance with aircraft noise." This includes high and moderate; it leaves out the "none" group—or little, and moderate, and high. And at less than 96 CNR, those with no fear and no misfeasance—the most highly predisposed to accept it—only 25 percent report some annoyance; 75 percent of that group, no annoyance. Now, what proportion of the population does this represent in order to get down to the total population, you would have to calculate. I really don't know offhand, but I would suspect that under 10 percent would be—probably under 5 percent would be the group who are so supersensitive—we have other general indices of sensitivity: dripping faucets, scratching chalk where we can measure noise sensitivity—that you are dealing with fairly small numbers and not with the magnitudes that EPA is really concerned about.

Dr. **von Gierke**. Paul, I heard some of these statements many times before, and I am always startled by the one jump we make in our conclusion that these so many percent have to be individual as supersensitive individuals, and I think this is not borne out by the data. It might just as well be that each of us is supersensitive to noise at certain time periods of our life or at certain periods of the year.

I mean mothers might be supersensitive to noise during the month they have young children, and they might perfectly be normal all through the rest of their life.

Dr. **Borsky**. This is a nonscientific term and perhaps we shouldn't use it, but by "supersensitive" I meant a person who would be reactive to a situation where you normally would not expect them to be reactive.

Certainly the individual is not general, he is very specific. If this is what you are saying, I fully agree with you.

Dr. **von Gierke**. They are not pinpointed to individuals. We only know it is a certain cross-section of the population we get in this type of surveys.

Dr. **Borsky**. I agree.

Dr. **von Gierke**. So it does not indicate in any way that there is something like a supersensitive individual as a personality.

Dr. **Borsky**. I think we do know this though—Milt may be able to support me on it—that there are people who have threshholds of sensitivity to all kinds of stress, and some more than others. And I really don't know the physiological reasons for this, that you could explain it. But there are some people, even with—well, certainly with recruitment—certain noises would be very painful, where others with normal ears you wouldn't be. So that there are individuals who probably can be—but they are a very small group —classified as being extremely sensitive.

Incidentally we are taking audiometry of all of our subjects, so we hope to be able to get some of this physiological stuff.

Dr. **Whitcomb**. I just wanted to comment that I don't know of anything that would lead me to believe that sensitivity to noises other than normally distributed in the population, which means that it is highly arbitrary where you put a cutting line on the wing of the distribution curve as to 5 percent, 10, or 20, or 50.

Dr. **von Gierke**. It is really more the complaint behavior we discuss, and the complaint behavior might change with time with the same individual.

Dr. **Borsky**. Or verbalize the annoyance.

Dr. **Meyer**. Well, I think this has highlighted part of the complexity that Sanford Fidell has also pointed out. We have got a whole flock of methodologies, many of which are based on this rather imprecise definition of human performance. We need to get closer to how we can define more reasonably or more usefully some of the internal characteristics of what is called the quality of life.

On that point, we will recess until 1:30, at which point we will resume this hearing with the afternoon's witnesses.

(Noon recess.)

## AFTERNOON SESSION

**Dr. Meyer.** I hereby call to order the fourth sitting of the EPA hearing on noise in the city of Boston.

Before calling the first of the afternoon's witnesses, I would like to announce that if there are those who would like to submit material for the record, they may address such materials to me as the Director of the Office of Noise Abatement and Control of the Environmental Protection Agency, Washington, D.C. 20460.

We would like to receive any such submissions within 2 weeks of this date because the final transcript will be submitted to the government printing office in approximately 1 month, and if we do not receive this within 2 weeks, it will be difficult to get it integrated into the testimony. But we will receive statements for the record in writing along with the suitable other supporting materials for the next 2 weeks.

I should now like to ask if Dr. Michael Baram of the Massachusetts Institute of Technology is here yet? I don't see him but I know he is on his way.

In the absence of and while we are waiting for Dr. Baram, who is next on the schedule, I would like to ask Dr. Robert Grenell of the Institute of Psychiatry and Human Behavior, University of Maryland, Baltimore, Maryland to come up and join us?

## STATEMENT OF ROBERT G. GRENELL, Ph.D., PROFESSOR OF NEUROLOGY, UNIVERSITY OF MARYLAND SCHOOL OF MEDICINE, BALTIMORE, MD.

**Dr. Grenell.** I wonder, Dr. Meyer, if I could just make a few remarks before my testimony relative to some of the discussion this morning.

**Dr. Meyer.** That is always in order, sir. We hope any witness will feel free to ventilate his views. Proceed, sir.

**Dr. Grenell.** I was very much interested indeed this morning in the discussion of animals versus people. I think there is no question that we would all agree that we would like to do all of the necessary work on people because that is the organism we are interested in. What I would like to say that wasn't quite said this morning—I agreed with practically everything that was said—but the one thing I would like to add is that one must, I think, consider the fact that to obtain certain specific kinds of information, one must on occasion use other organisms. They are necessary for preparations which one cannot use human beings for.

Now, the consequence of this is not the difficulty with the fact that you are just carrying out an experiment on an animal, it is the difficulty with the interpretation you make of the results, and I think that this is where the limitation is, and one should be aware of that.

But there are times when there is no other way of doing something other than to use some particular kind of preparation, whether it be—it in certain instances may even be a plant.

Now, there also, I think, in dealing with various kinds of measurements that people sometimes use—measurements, for example, of blood cells, or constituents in blood, or things of this nature. I think it important also to remind people that it is necessary to take into account things like circadian rhythms. If one does not establish a base line relative to this phenomenon of circadian rhythms, the interpretation of changes that one gets is certainly questionable because you have established no real control.

Now, as far as Dr. Fidell's point—one of his points this morning, I agree wholeheartedly. I think certainly that no one—I doubt that anyone this morning or any other time—would really seriously deny that the only way to approach any kind of sound research is to start out with a hypothesis that is based on available information, literature, experience, judgment, training, and all kinds of things, and attempt to set up a program in such a way that you know what assumptions you are making and you attempt to validate the assumptions and in so doing validate or not the hypothesis.

So that the main thing, I think, is to keep one's self out of the experiment, as somebody once said, and if one does that, I think the likelihood is that, using any reasonable kind of thought, all of us would support that kind of approach rather than some disorganized one or nonintellectual approach. Arguing against that would be sort of like to a research scientist arguing against mother, God, the American flag, and apple pie.

Now, to come to our testimony, I would just like to make this point about it. It is, in many instances, a superficial discussion, which is designed to do just three things: 1) to give some background relative to a definition of noise which we feel we have to have in order to approach neurophysiological and behavioral problems. The difficulty, it seems to me, in some areas here, is that we all use the word "noise," but we never know quite what the other fellow means by the word.

I was, to some extent this morning, a little surprised when I heard someone say that to deprive a human being of noise would be just as deleterious as too much noise, when what I think he meant to say was that to deprive him of sound would be just as deleterious. There is a tremendous difference between sound and noise.

So that I think, then, that we have to at least establish for our own purposes as investigating certain problems in our particular area what our definition is, and we are trying to do that here.

2) The second point of the testimony deals with certain considerations relative to the central nervous system neural process, which we feel is of great importance.

3) And the third point is merely to suggest certain areas for investigation relative to this problem.

As I say, it is a superficial discussion. We have had to touch on many things lightly and in certain areas to touch on things in which we are not at all experts, and I hope that will be understood.

Consideration relative to a program of noise abatement and control—excuse me one minute, I might insert something else. And that is that we are concerned here not with extremes of noise or rare noise problems, but we would like to consider the problems we have to look at in people's brains as problems related to a chronic environmental noise situation.

Now, nobody else has it, but if the panel will look at the title page of this testimony, they will see what happened to my secretary, who is subjected to an unfortunate level of chronic environmental noise, and she typed on here University of Maryland School of Maryland instead of Medicine. She happens to have in her office an electron microscope power supply, a water cooler, an air conditioner, a telephone, some buzzers, and people.

Dr. **MEYER.** Maybe the people are part of the problem.

Dr. **GRENELL.** Considerations relative to a program of noise abatement and control cannot preclude the investigation of the possible brain effects of noise. This is a sine qua non. With the best of intentions, millions of dollars could be wasted if an abatement program does not rest on a sound biological basis. What we mean by this—I would insert here—is just that if we do not understand what the mechanism is of what might possibly go wrong in the brain, or how to correct it properly, we can spend an awful lot of money in the wrong direction—is all I am trying to say by this.

When people are exposed to environmental noise signals, high level and otherwise, we must examine the possible neurological consequences of those signals along the entire auditory pathway, not just at the ear. We must know whether noise damage is confined to the ear, or whether extended or intense noise exposure also results in the erosion of brain function. In this discussion, I would like to mention, in broad outline, those neural mechanisms and functions which might be particularly affected by the environmental noise content. I will also suggest a number of investigative approaches which might elucidate these effects. The problem will be introduced by touching on three relevant considerations:

1) the "noise" signals themselves;

2) mechanical and electrical consequences of intense noise exposure in the peripheral auditory process; and,

3) the auditory pathway, and its mid-brain and cortical connections.

Finally, possible noise effects on structure and function at a number of foci of the central auditory process will be suggested.

Particular neurophysiological and neurochemical techniques may be related to the study of noise effects at the central auditory level. These include local perfusion, labelling techniques, signal analysis of both gross responses and single-unit activity, RNA analyses of subcellular neurone fractions, neuropharmacological techniques, and a number of other approaches. I will attempt to show the relevance of a particular method in the discussion of noise effects on the central auditory process. It is hoped that the discussion may also stimulate other investigators to initiate new and original proposals in this area.

One may find three principal rationales underlying the classification of acoustic signals as noise. These arise from the discipline which forms the point of departure of the discussion. In communications, noise is the superposition of signals extraneous to a message term which embodies information. Noise is therefore studied on the basis of its interference with the information signal. A "good" or high-signal to noise ratio, S/N, is of equal value with low distortion in effective acoustic communications. Topics of interest in this field include: noise intensity, noise bandwidth, its spectral energy density distribution, and its frequency relationship to the information signal. S/N ratios at synapses (neural junctions) in the brain are of importance here.

In signal analysis, a general noise signal is considered to be an aperiodic signal of infinite bandwidth. Thus the mathematical basis for its analysis begins with a statistical approach. Discrete periodic signals, on the other hand, are amenable to time-domain analysis. The Fourier transform relationships may exist for some of these signals, and thus they may be amendable to frequency-domain analysis as well, either directly or in terms of their time-averaged power or energy. A discrete, periodic signal may be the superposition of simpler periodic signals which are harmonically related, as in some speech phonemes. In harmonic analysis, the greatest distribution of these components is of interest. In special cases of band-limited ergodic or wide-sense-stationary random signals, statistical correlation averages may converge to a common result with time averages, and they may be examined spectrally. Topics of interest to the signal analyst include the statistics of random noise signals, the periodicity of discrete signals, and those cases in which a particular signal may be amenable to frequency-domain analysis.

The experimental psychologist considers the subjective response of man and the higher vertebrates to acoustic signals. His interest is in the effects of noise frequency and noise intensity on hearing thresholds and on the degree to which threshold shifts consequent to intense or prolonged noise exposure may be temporary (TTS) or permanent (PTS). He is also interested in the making effects of these signals on auditory perception of acoustic information signals. Thus his description of noise is perhaps the closest approach to common usage of the term "noise," since a noise signal may be described in terms of its discomfort, distracting effects or irritability. Topics of interest to the experimental psychologist are the degree to which intensity, frequency, and duration of noise exposure affect hearing thresholds and mask acoustic information. Obviously the experimental psychologist shares many of these interests with audiologists and other auditory specialists.

All three rationales are germane not only to noise abatement and control but also to particular anatomical and physiological concerns in the auditory process. I will, therefore, attempt to define a noise signal by making use of concepts from each approach. In this formulation, ideas which are common to all three approaches will be stressed.

The most general form of acoustic signal will be a random noise signal, aperiodic and nonstationary statistically. Such a signal would itself have information capacity by its off-on" perception with relation to some external event, as in conditioning. But its information capacity increases as the signal becomes progressively qualified both temporally and spectrally, since the number of patterns which may be formatted to carry information will also increase. An optimum condition will exist for the encoding of a single information "channel," defined by frequency, time, etc. We know from information theory that this optimum must be finite. But it will not necessarily resemble the optimum information capacity of the communications system as a whole. Again, the optimum system capacity will not necessarily be optimum to a particular source or receiver, and it is evident that in discussing optimum criteria, we have opened up a veritable "Pandora's Box" of interrelated factors.

For the moment, I will consider the system to have information capacity beyond that of any particular source or receiver, which in this case becomes the human ear. The controlling optimum criterion will therefore be that of the auditory, discriminatory and immediate perceptual capacity of a human listener. The acoustic signal may include the superposition of more discrete components, a broader frequency pass-band, or a faster-changing pattern of signal variability than is called for by the optimum auditory capacity of a particular listener. In this event, a new form of noise signal is introduced at the ear. It is interesting to note that the extrapolation of excessive signal complexity to its ultimate form will result in precisely the type of random, unstationary noise signal with which this discussion was begun. The optimum conditions for human communications would appear to exist when the number of nonrandom signal components precisely matches the sum of signal sources to the most favorable acoustic analysis capabilities of the ear and to the immediate perceptual capacity of the brain. In this, I presuppose that extraneous signals are absent and that this brain has been formatted to process and interpret the acoustic information signal. In other words, I presume that the listener has achieved a stage of cognitive development which permits his immediate recognition and perception of what is heard and permits the suppression of extraneous signals at the conscious level.

The intensity of the signal will also have a frequency-dependent relationship to its perception. An optimum value would be expected to be well below the feeling threshold in normal hearing, since high-intensity sounds will produce a variety of avoidance reactions in the listener. Avoidance patterns would interfere with the hearer's ability to focus his hearing and perceptual apparatus on the information content of the acoustic signal. Similarly, the intensity of an extraneous or "unwanted" signal would become as important as its relative frequency in determining its interference with an information signal. A point would be reached when the latter was entirely maked by the noise signal.

Thus we have laid the foundation for the three criteria with which I will, pro tem, define a "noise" signal for our purposes:

1) The existence of a greater than optimum number of signal components in the transmission of information. These components may arise from an extraneous signal or from an information signal which is itself too complex for optimum perception.

2) The existence of any audible signal components which are lacking in information content to the listener.

3) The existence of any acoustic signals of greater than optimum intensity, whether as extraneous masking signals or as an information signal which is "too loud," so to speak.

The addiction of hi-fi enthusiasts and of the "with it" generation to sound levels which may surpass 120 dB feeling thresholds in SPL gives one pause as to where, and indeed as to whether an optimum intensity level should be established.

I might add at this point that when we were talking this morning about the relative benefits of quiet as opposed to noise—even this is not an easy problem to deal with because for some people the noise of the crickets in the country drives them up the walls, and I think we have to consider some of the other factors in dealing with what is quiet. We don't even know that as a matter of fact.

I now proceed to a brief consideration of what is known of the effects of the above noise signals on the peripheral hearing mechanism in higher vertebrates including man. One immediately notes that current structural evidences for the effects of noise derive primarily from signals of the third category. That is, most of the effects have been observed from signals of sufficient intensity to alter mechanically structures located in the middle and inner ear and in the vestibular apparatus. Mechanical assessments have been made on the basis of the type, duration and intensity of the acoustic stimulus. The signal characteristics have been related to the site of mechanical deformation or disruption and to the type of damage whether gross, cellular, or subcellular.

(Slide.)

Dr. Grenell. It would be difficult if not presumptuous to single out the work of only a few investigators from the superb and substantial body of research in this area, but I must risk the omissions. This slide is one in a series of remarkable scanning electron micrographs by Hans Engström. (1) It shows the normal sensory hair cells in Corti's organ of the guinea pig. And the second slide will show damaged hair cells.

(Slide.)

This shows the damage as compared with the other slide. This shows local damage to the outer row of sensory hair cells in

Corti's organ after the animal had been exposed to laser beams. Although the stimulus in this case was not of acoustic origin, the evident damage may well have resulted from subharmonics excited by the beams. The massive area of damage could be considered somewhat atypical of high intensity noise signals, per se, which appear to exhibit a spottier pattern of destruction. Such evidences have been clearly associated with permanent hearing impairment.

In a brief survey, one can only mention the research effort now being undertaken on the chemistry of lymphatic fluids of the vestibular labyrinth and organ of Corti as a function of acoustic input.

The electric potentials identified in the peripheral auditory system are well known and need no substantive discussion here. Nonetheless, it might be of interest to recall the effect of acoustic signal intensity on the cochlear microphonic response, summating potentials, and the action potentials, particularly the $N_1$ spike. This slide is from the discussion by Hallowell Davis (2) in "Neural Mechanisms of the Auditory and Vestibular System." It shows for each response, the log of output in millivolts versus sound pressure level of the input in dB. In this case, the acoustic input was a 7 kilohertz tone burst series, but similar results have been observed when random noise signals were used. Note particularly that only the CM peaks below 120 dB SPL. The negative summating and action potentials continue to increase as some function of the root mean square value of the input signal into the feeling threshold.

The cochlear microphonic and negative summating responses have been investigated in terms of the mechanical vibration modes at the basilar membrane and elsewhere. Von Bekesy's (3) notable work has included the mechanical analysis of bending and shear forces on sensory hair cells and their relationship to the active generation of bioelectric signals.

(Slide.)

The relationship of these responses to endocochlear potentials and to ion fluxes has also come under considerable scrutiny. Stopp (4) perfused the scala tympani with Ringer's solution in which the sodium was replaced by lithium, as shown in this slide. Results showed that the CM, negative summating, and $N_1$ responses were not affected. However, the afterpotentials were completely abolished, reminiscent of the abolition of neuron afterpotential in the absence of sodium after repeated stimulation, as discussed by Ritchie and Straub (5). These findings suggested to Stopp that the two phenomena might have a similar origin. Parallel results with metabolic inhibitors were found by her to be consistent with the hypothesis that the afterpotential arises within the "synaptic cleft" between the hair cells and the afferent fiber terminals. In this event, the $N_1$ response might be a form of post-synaptic potential rather than the summation of the potentials for fibers in the nerve trunk per se, which is a more generally accepted notion. This work brings into question the origin of the $N_1$ response. It illustrates the value of a broad-based, multidisciplinary attack on the peripheral auditory mechanism.

(Slide.)

In a classic study, Katsuki (6) placed thin microelectrodes in individual fibers at various sites of both afferent and efferent auditory pathways. He confirmed the sigmoid relationship of spiking frequency to sound intensity in the cochlear nerve. There was evidence of decreased intensity effect on single unit firing rate as fibers were progressively monitored along the afferent pathway to the subcortical level. "On-off" responses appeared from the level of the inferior colliculus.

With this discussion, we have strayed into the territory of the central auditory process. But we should give brief mention to the peripheral process of frequency discrimination and sound localization at the inner ear. Functional aspects of the cochlear partition as an acoustic analyzer have been extensively investigated. The process of frequency discrimination is still not entirely clear, and the place-periodicity controversy has not as yet been completely put to rest. Nonetheless, it appears that both the cell firing characteristics and their locus of innervation are used to convey frequency information to the brain.

Monaural sound localization is not completely understood, but it apparently involves the conversion of more acoustic information than is given by intensity alone.

Less well understood is the specific organization of neural information in the peripheral fibers. From what is known of this organization, it would appear that not one but a number of pulse codes may be used simultaneously in the peripheral encoding of acoustic signals. This field includes some of the more elaborate investigative schema of the current research efforts on audition, and its offers unusually arduous technical and mathematical challenges to the scientist.

(Slide.)

In this slide we see the afferent auditory pathway to the brain. This is a somewhat simplified arrangement. As is well known, the more recent work of Galambos (7) and of numerous other investigators has shown that in unaesthetized animals, collateral branches from other areas are also interconnected. Much of the work done on anaesthetized animals must be redone. A good deal of the work in the central nervous system was done years ago on central anaesthetized animals and cut out of the observation all of the lateral connections of the auditory system to other areas of the brain.

The central connections of the direct auditory system are well defined. The bilaterality of the system is clear. Unilateral cortical lesions affect hearing only slightly, and since both auditory areas are seldom attacked by the same pathologic process deafness is rarely produced by cortical lesions.

In addition to the specific projection to the auditory cortex a more diffuse route can be traced through the reticular formation. Although several major stages here are undefined, the ascending reticular system is clearly implicated by the observation that sounds continue to arouse decerebellate cats after the specific auditory system has been severed. It has even been possible (as shown by Galambos and his group) to evoke a "normal" auditory primary evoked response in the cortex of the cat after complete transection of the brachium of the inferior colliculus.

The effect of "noise" on the olivo-cochlear bundle of Rasmussen is also a question of great interest. Galambos was able to alter the response of the auditory nerve to click stimuli by applying electric shocks to this bundle. When the muscles and ossicles of the middle ear were removed and the animal was curarized, the suppression began 20-30 msecs. after the first shock of the train of stimuli and continued as long as 500 msecs. beyond stimulation. The outer hair cell response (cochlear microphonic) was unaltered during these maneuvers, but the auditory nerve response was suppressed (strong clicks) or totally abolished (weak clicks). It is evident that the central nervous system can modulate its input via this system; malfunction of the system could result in significant shift from normal hearing.

If the central auditory process could be characterized by one understated word, that word would be "complex." We know that there are 30,000 odd fibers in the spiral ganglia for each ear. Chow (8) has shown that for each of these fibers, two issue from the cochlear nucleus, 14 issue from the medial geniculate, and 340 occur in the auditory cortex.

In terms of direct fiber elaboration alone, there are, then, some 20 million cortical connections associated with the 60-odd thousand auditory fibers arising at the basilar membrane. Form the product of cortical connections and the multiplicity of codes which may be used by the system and you have a pretty large number. This number increases with the number of collateral pathways, the efferent "control" system, the possibility of coding hierarchy, and the complexity of synaptic terminations for a single fiber of a spiral ganglion. Indeed, the permutations seem to be of an impossible magnitude.

But this should not discourage the investigation of the central auditory process, nor has it discouraged the excellent beginnings which have been made in coming to grips with its features. It merely serves to warn us of the formidable magnitude of the problem. As a consequence, it should not surprise us that our current knowledge of this system is, in a word, primitive, even by comparison with the peripheral auditory process.

It is the contention here, however, that we must tackle this system, above all others, if we are to really come to grips with the subtleties of environmental noise pollution. There are a number of reasons for this. I think they may be summarized by considering the enormous gaps in our understanding of the still dark area between the peripheral process of the sensory encoding of the acoustic noise signal and the subjective rating scale which is used by an individual to assess his perception of noise. Questions might be postulated to illustrate the importance of the central process, which represents this gap, such as—some of them we have put here just off of the top of our heads. For example:

1) What central processes are involved when an individual shows repeated annoyance at certain categories or noise and not others?

2) Why does hallucination include such clear replicas of certain perceived sounds and what is the relationship of hallucinatory

disorders to the acoustic noise environment?

3) What central mechanisms are involved in the perceptual process of rejection of extraneous sounds?

4) Why do some noisy environments produce continued headaches in factory workers? What central processes might be involved?

5) Why do other occupational noises make so many people sleepy? Are there particular central processes involved in this effect?

6) Why do certain categories of noise trigger emotional reactions in the hearer? Is the limbic system involved?

7) Why may noise signals be used to mask the sensation of oral pain in dentistry?

A very long list, indeed, could be made of noise effects which cannot be answered in the light of our present limited understanding of the central auditory process. More important, it seems evident that the answers to these questions may lie almost entirely within this central process. That, or they, will never even remotely be understood in the absence of a far more complete evaluation of brain anatomy and function with respect to hearing.

Hopefully, we have established the complexity of the central auditory process and the need to study noise effects at the brain level if we are to formulate a proper program of noise abatement and control. The question might well be asked: If this system is so complex as to virtually defy analysis at this time, why should a program of research support in this area be undertaken? What short-term benefits could accrue to the program if no definitive answers are in sight? The answer, I believe, is that a great deal of useful information about the brain effects of acoustic noise could be accumulated in a reasonable period of support in spite of the incompleteness of our understanding. This has been true in other fields, and there is no reason to suppose that the harvest won't be pertinent and valuable to a noise abatement program.

The first point to be made in this regard is that a good deal is known about the central auditory process at the present time. We have clear evidence, for instance, that frequency localization and intensity discrimination of acoustic signals takes place as much in the central process as in the peripheral auditory mechanism. Galambos, Rose, et al (9) have shown that the cochlear nucleus is, in the words of Towe, an "uncoiled reflection of the cochlea," with tonotopical neuron arrangements ordered into full tonal spectra in each of its three major subdivisions. There is evidence of tonotopic architecture in the inferior colliculus and, of course, in the primary auditory cortex, etc.

What does this organization mean in terms of environmental noise? We know that functional localization occurs in the peripheral process and that particular mechanoreceptors are subject to deformation and damage, both reversible and irreversible, if the intensity of signals of a certain frequency exceeds certain levels. Can we simply dismiss the possibility that some form of parallel effect might occur as a part of the central process when the elaborate pulse activities associated with the conversion of noise signals appears at some centrally located synapse? Such an effect might or might not appear in ultrastructural electron microscopic examination of the synaptic area, but it might well become evident through a series of carefully designed single-unit studies of activities of a number of fibers which made synaptic connection with an afferent fiber from the cochlea.

The argument against this hypothesis would be that the peripheral process involves mechanoreceptors, and these would be considered to be mechanical limiters, which would be damaged or destroyed if acoustic pressure excursions in excess of their tolerances were encountered. Since no such vulnerability would be found in the central neurons, the only neural processes which could be affected by mechanical damage would be those associated with their innervation. Thus it would protect the central mechanism in its own destruction.

The argument may well be fallacious. It presumes that the electrical pulse encoding of acoustic signals can have no parallel effect of its own on synaptic terminations and on the activation of new afferent pathways as well as of new efferent controls over a relatively massive system of pulse stimuli. Or it presumes that whatever central pulse effects occur as a function of the noise input, these effects are short term, reversible, and in no sense debilitatory to the central auditory process. Frankly, the bland acceptance of such a view would appear naive.

In the brief time available here it is not possible to go into lengthy neurophysiological detail. It is essential, however, to carry the central neurophysiological problem a bit further. We have already noted the vast complexity of central connections involved in the direct system. Auditory connections to other vital functional areas of the brain become of major importance to the integrity, health and performance of the organism. There are auditory inputs to such centers as the hippocampus and cerebellum, both of which have been demonstrated to be involved in emotional responses and behavior. No auditory input, and particularly no noise input escapes connection with both the reticular activating ("arousal") system and so-called automatic centers (centers involved with operation and maintenance of the internal environment of the organism). To understand fully the possible effects of chronically variable and increasing noise input, experimental studies must take into account concomitant alterations in pulse rate, blood pressure, respiration, glandular secretion, etc. In a number of instances this has been done, but only to a limited extent. It would not seem improbable that an unheralded effect of our noisy environment is the role it may play in the etiology of some so-called psychosomatic illnesses, as well as in the ever-increasing stress which leads a society to the consumption of tranquilizers and other drugs. A vast amount of investigation must be carried out in these interdisciplinary areas. Dr. Kryter (in his important book, "The Effects of Noise on Man") has summarized the literature relative to general physiological responses to noise. Although many experiments demonstrate an apparent adaptation of the organism to sustained noise, it is important to recognize that this so-called adaptation involves an active process of inhibition which, indeed, becomes more and more ineffective as decibel levels are increased. I have some feeling that neither the mechanism nor real meaning of what has been referred to here as adaptation are clear. The whole concept of "adaptation" to stresses of various sorts adds many complex and hazy notions and problems to the analysis of the central one under discussion. I doubt that anyone at the present time can describe in no uncertain terms the neurophysiological properties of "adaptation."

I should like to mention one additional problem that is of interest at least to me. It is obvious that as unwanted input increasingly comes into the brain, it becomes more and more necessary for the brain to do something to prevent it from interfering with appropriate, goal-directed behavior with the focusing of attention. I think this is one of the things we are talking about here. We are not talking about whether people are happy or not happy, or irritated or not irritated; we are talking about can they perform their goal-directed tasks with the best productivity, creativity, and other things, or not. It is obvious that the brain cannot respond appropriately to all the barrage of input to which it is continually subjected. Consequently some of the input must, in a sense, be cut out. In the case of noise, the brain can, up to a point, use this cutting out ability. However, not only is this ability limited, but its continued operation suggests that numerous other excitatory and inhibitory brain circuits are being forced to function beyond "normal" or usual levels. The implications of such activation are enormous relative to fatigue, aggression, neurotransmitter synthesis, storage and release, certain transducer properties, etc.

In summary, then, we are unequivocally of the opinion that exhaustive investigation of central auditory processing is not only essential, but will yield information of fundamental importance to a noise abatement program. In fact, it would seem that only through such studies can be obtain the data necessary to make certain rational suggestions concerning prevention of the effects of noise on the functioning organism. The work must proceed at all levels including not only the psychological and neurophysiological ones, but also their most refined neurochemical, biophysical and ultrastructural correlates. At present we are ignorant in some appallingly obvious areas. Some of these include, for example:

1) Differences in brain, behavior and performance in animals—and there is a distinct difference between behavior and performance that we can't go into here—raised from birth in a no sound environment, in a sound-controlled environment, and in an environment of continually increasing noise.

2) Although a number of investigations have been concerned with certain aspects of noise effects on mental and motor performance, there has been almost no sophisticated investigation of emotional factors and behavioral status in man studied in an environment where controlled sound and noise input is available simultaneously with the necessary tools and arrangements for assessing the relation of a disturbing or unwanted sustained or random noise input to patterns of frustration, motivation, and

other forms of behavior. A controlled environmental chamber of such a type in which a man can live for some days or longer is available in our Institute at present, (in the laboratories of Dr. Russell R. Monroe) and would allow for some studies of great interest and significance.

I have already raised several points with regard to noise signals and to their reception and transduction at the inner ear. These are relevant to this discussion of noise effects on the central process as follows: The pro tem definition of the signals themselves is essentially a quantitative one, in which I postulate that signal content constitutes noise when it is in excess of an optimum number or arrangement of signal components or an optimum intensity. I have also illustrated that a number of well known electrical responses increase with noise signal intensity, and that intensity is proportional to firing rate in the lower fibers along the afferent pathway. It is also evident that the frequency bandwidth of a signal determines, to a considerable degree, the number of fibers which are excited, in that some form of tonotopical organization exists at both peripheral and central sites.

These considerations would appear to support one inescapable conclusion: that among the effects of peripheral signals on the central process, single unit excitations along the lower afferent pathway are quantitative with relation to the intensity and bandwidth complexity of the acoustic signal. Indeed, excitations may also be quantitative with regard to the complexity of their pattern of presentation, since this relates not only to the acoustic information content but to certain startle reactions as well.

If this is indeed the case, then one or both of the following consequences might result in the brain:

1) Its overall neural activity would be increased, even in areas somewhat remote from the auditory system, since collateral pathways would become involved.

2) Its efferent feedback control mechanisms would be quantitatively involved in the suppression of extraneous signals. Thus the ramifications of extended or prolonged noise exposure might not necessarily be confined to the central auditory process, and we might find sound empirical explanations for the complex reactions to environmental noise which are observed at the behavioral level.

Equally important, a number of neurochemical and neurophysiological techniques could be brought to bear on the elucidation of both reversible and irreversible brain effects of these signals, as suggested at the beginning of this discussion. Thank you very much.

(The references cited by Dr. Grenell and the slides shown during his presentation follow.)

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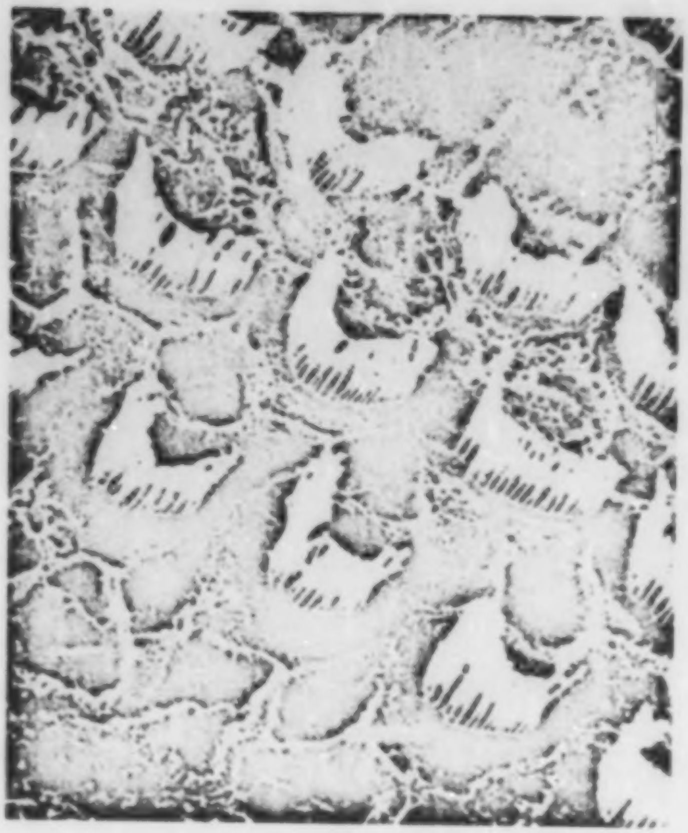


FIG. 1-A

NORMAL

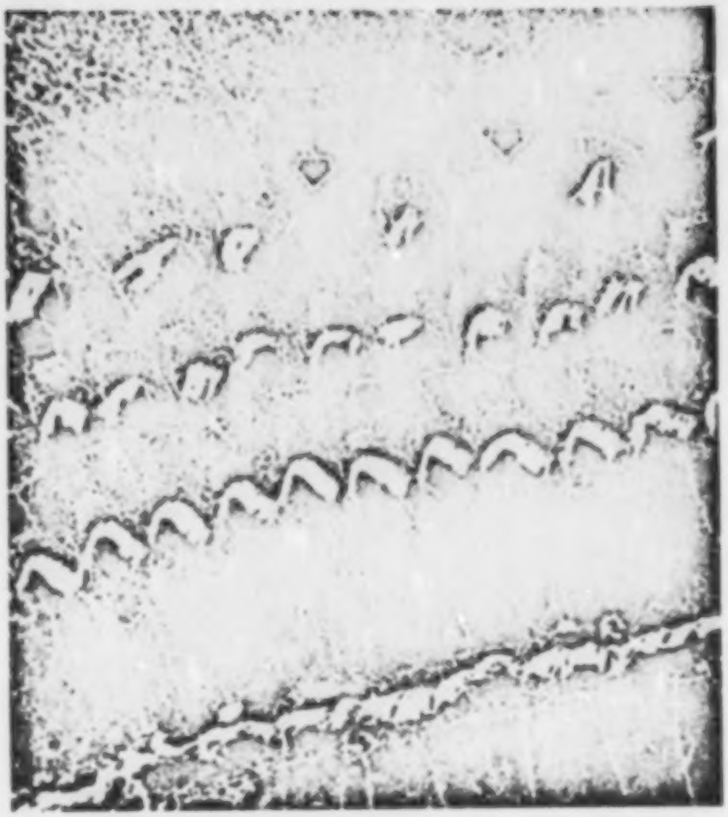
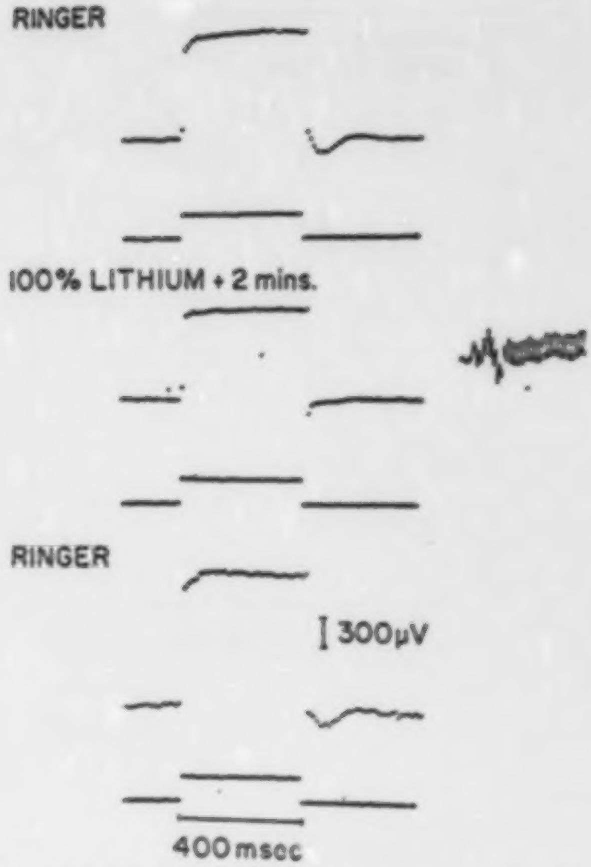


FIG. 1-B

DAMAGED



[illegible]

FIG. 3

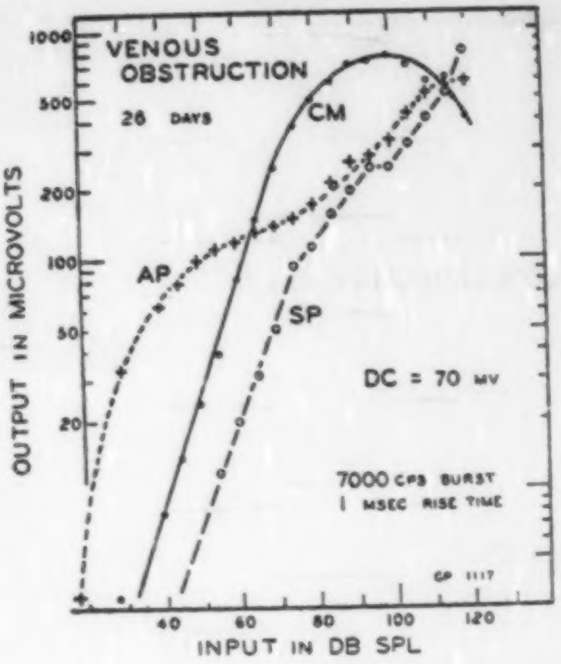

VENOUS
OBSTRUCTION
26 DAYS
CM
AP
SP
DC = 70 MV
7000 CPS BURST
1 MSEC RISE TIME
GP 1117
OUTPUT IN MICROVOLTS
1000
500
200
100
50
20
INPUT IN DB SPL
40
60
80
100
120

FIG. 2

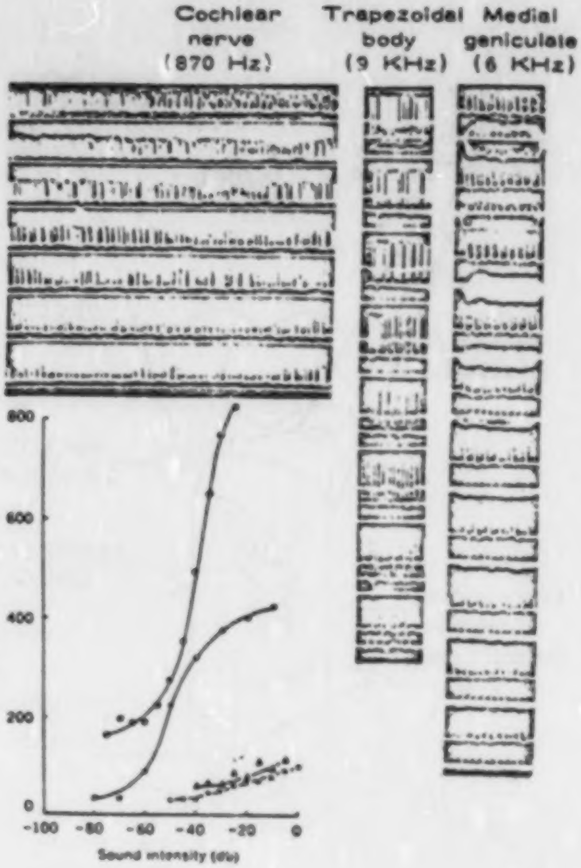

Cochlear nerve (870 Hz)
Trapezoidal body (9 KHz)
Medial geniculate (6 KHz)
Spike frequency
800
600
400
200
0
-100
-80
-60
-40
-20
0
Sound intensity (db)

FIG. 4

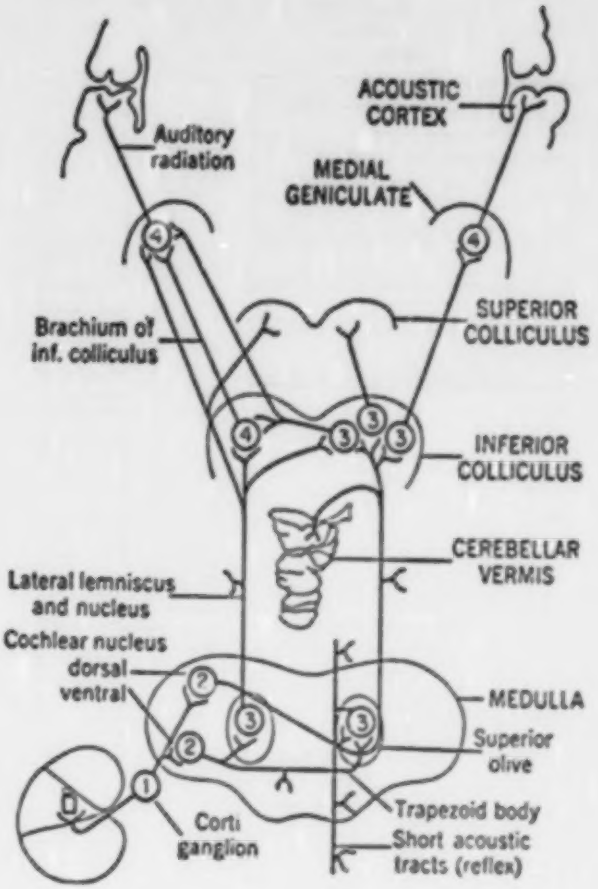

Auditory radiation
ACOUSTIC CORTEX
MEDIAL GENICULATE
4
4
Brachium of inf. colliculus
SUPERIOR COLLICULUS
4
3
3
3
INFERIOR COLLICULUS
CEREBELLAR VERMIS
Lateral lemniscus and nucleus
Cochlear nucleus
dorsal
ventral
?
3
3
MEDULLA
2
Superior olive
1
Trapezoid body
Corti ganglion
Short acoustic tracts (reflex)

FIG. 5

Dr. **Meyer.** Thank you, Dr. Grenell, for a very detailed presentation of an extremely difficult subject from which I find a lot of important things for us to consider, and before I ask a question or two I will ask the panel—Dr. Eldredge?

Dr. **Eldredge.** This is certainly an almost exhaustive list of things that we don't know, and this makes it a little bit hard to comment on and even to discuss from that point of view.

As a matter of fact, I see you have recommended quite a package, looking at the effects of noise on all levels, and I think the only thing that you might add here would be to try to do something that you sort of avoided, and that is say, well, what would be the rank order of priorities that you would put on the various levels of behavioral investigations as opposed to going straight—forgetting the animal's behavior or man's behavior and go straight inside the brain.

Dr. **Grenell.** Well, as you pointed out, that is a difficult question to answer off-the-cuff, so to speak. I think one would have to give this very, very much more considerable thought before giving any rank order of approach to these problems which would really, I think, be meaningful. However, I think that there are those of us, I am sure, who will be driven in certain directions by our previous experience and previous training, etc., etc., as always. And this may be one of the things we have to control.

I personally, just to make some attempt to answer this very important question, would be inclined to feel and we ought to do at least in the terms of the kind of things we have available to us in our institution—if you can put it in that kind of microcosmic setting for an answer at the moment—to start on two levels: 1) to start experiments on man himself from the behavioral point of view in a controlled chamber; and 2) simultaneously to start primate experiments on the—well, two aspects. The first one that I feel I would personally be impelled to do would be the developmental study, because I have absolutely no knowledge of what happens when one is subjected to—raises animals in different controlled environments. And I would like to begin certainly to look at the brain and at various areas of the brain under those conditions.

Dr. **Whitcomb.** Not only is the work list exhaustive but it is exhausting when one considers doing all this and having adequate controls.

For example, working with unanesthetized animals, which you quite properly mentioned, and then referring later in your paper of the need to monitor units for single fibers presents no small problem of holding—

Dr. **Grenell.** We do it all of the time. You can hold—if you are lucky—let me put it this way: On experiments of this nature, I think I would be willing to state to you that if you have one good experiment out of five, that is a good average.

If you can, on the average, keep a microelectrode in a cell for 7 to 10 minutes, you are doing very well. On the other hand, you, in some experiments, can keep them in for an hour.

Dr. **Whitcomb.** I was thinking of the possibility of holding a unit over a prolonged time, which is what I thought you were suggesting—

Dr. GRENELL. It is impossible so far.

Dr. WHITCOMB.—like days.

Dr. GRENELL. Can't do it. You can do it with an extracellular electrode but not an intracellular electrode. It is impossible.

Dr. WHITCOMB. Then, I add my comment to Don's that I think you had an excellent presentation.

Dr. GRENELL. Thank you.

Dr. VON GIERKE. I have very little to add to this. I guess it just points out the continuing need for basic research in all these areas.

I have some question on your definition of "noise," but I don't think it is too relevant. I feel one has to add another definition to it because, as you point out later in your paper, the final decision, if some mixture of signals or what signal in a mixture of signals is noise, and what is "signal," is to be made by the brain.

Dr. GRENELL. Right, right.

Dr. VON GIERKE. So the information has to go up all of the way first—

Dr. GRENELL. Right, right.

Dr. VON GIERKE.—for you to make the decision.

Dr. GRENELL. Right.

Dr. VON GIERKE. Secondly, you define it as "any signal which is lacking in information." I think many signals have negative information; like, for example, the airplane noise. It is a definite—

Dr. GRENELL. Yes.

Dr. VON GIERKE.—signal, as we discussed.

Dr. GRENELL. This should have been included, yes. That should be added very definitely; no question about it.

Dr. VON GIERKE. And then finally you say the "existence of any signal which has more than optimum information"—I mean this raises the question: what is optimum acoustic information?

Dr. GRENELL. Well, this is what I mentioned, you see.

Dr. VON GIERKE. But I think we know—

Dr. GRENELL. I don't know.

Dr. VON GIERKE.—we know that our speech is basically defined the way it is because we live in a noisy environment; speech is terribly redundant. If we would know that we would have only man-to-man communication in a quiet environment, we could make our speech signals much more simple.

Dr. GRENELL. True.

Dr. VON GIERKE. So I think we should not overlook that I think our whole acoustic processing system as well as, I think, the brain in general are built to operate in a noisy environment, and to—excuse the expression—to adapt to this noisy environment.

Dr. GRENELL. Oh, I agree. I have nothing against the word "adapt"; I just don't know what it means. That is different.

Dr. VON GIERKE. I think—

Dr. GRENELL. I mean I don't know what it means neurophysiologically.

Dr. VON GIERKE. The change in performance and function as a result of environmental inputs.

Dr. GRENELL. Yes, but neurophysiologically, you see, I can't explain this, and this is one thing I would like to be able to explain. I would like to be able to tell you, in terms of exactly what is going on in the brain, what that means when you say something "adapted." I have no way of doing this at the moment.

Dr. VON GIERKE. Then, finally, I think your whole concept, framework for this investigation raises a question: What is overstimulation of the central nervous system? And this can occur not only due to noise.

Dr. GRENELL. That is quite right.

Dr. VON GIERKE. I guess you can have overstimulation through intellectual stimuli, and many of us worry about this in the educational process with our children today—

Dr. GRENELL. Yes.

Dr. VON GIERKE.—and I think it is—

Dr. GRENELL. Well, this is why—

Dr. VON GIERKE.—part of the whole problem.

Dr. GRENELL. Dr. von Gierke, this is why I suggest that one has to use more than neurophysiology to deal with such a problem. There are ways, for example, neurochemically and physically, to at least look at some things we know so far are related to overstimulation of nerve cells.

Dr. VON GIERKE. Right.

Dr. GRENELL. You know, we have, for example—

Dr. VON GIERKE. And that has very little to do if it is signal or noise.

Dr. GRENELL. That is right. At least so far.

Dr. VON GIERKE. So far.

Dr. GRENELL. I don't know enough to know where the line is.

Dr. VON GIERKE. And then one minor point of interest. You quote continued headaches of factory workers in some noisy environments. Do you have any specific noise environments in mind? I am not aware that there are specific environments which produce headaches in some individuals.

Dr. GRENELL. At this moment, I don't recall. We got this reference—and I have it back at the lab; I will look it up—but at this moment, I don't recall whether it was a specific occupation. I think there were some occupations as I recall.

Dr. VON GIERKE. The only reference I know is by Dr. Jansen in his survey of a thousand factory workers where many different stresses were combined with the noise stress.

Dr. FIDELL. Well, let me start out by saying that I do admire the comprehensiveness of the document. But I have an uncomfortable feeling that it's the inappropriate level of analysis for noise pollution studies. It seems too fine grained. Let me see if I can justify that. It is the sort of "you can't get there from here" approach.

Let me start off by reasoning by analogy. You know for a long time after Hubel and Wiesel discovered these complex feature extractions, there was no evidence that they were functional. So what if you think you have a detector, show me what that does to vision. And that is still a topic of some debate.

And by analogy, if we were to know what happens at the synaptic level, and so forth, it is not clear to me that you would have any way of predicting what effects that would have on grosser effects of the sort which EPA, I suspect, would want to deal with. Then you also have degrees of freedom problems. So what if you knew? What would you do?

For example, what implications does knowledge of the transmission of synaptic cleft information waves of the brain have to do with controlling aircraft noise?

Dr. **Grenell.** It just doesn't have anything to do with it obviously which you know as well as I do. (Laughter)

Dr. **Fidell.** Sure. But the point I am trying to make on this level of analysis thing is that here is the Environmental Protection Agency and they are charged with, you know, taking care of some of these everyday problems. I think it is fine basic research and, you know, if I had the money I would fund it myself. But I don't see that the EPA—

Dr. **Grenell.** Obviously I see what your point is. I am not sure I can agree with it. In other words, I think that this point always arises in any situation like this. How basic is it proper to go in dealing with a problem a society has, let's say, which is one that one tires to settle in the most efficient, cheapest, etc., etc., etc. way.

Now, in a sense, if one were to say, for example, we will just do this kind of thing and nothing else, I would be dead against it. This is not what I am implying at all. I assume naturally that there are going to be studies on other levels going on simultaneously—this is number one. However, to carry on other studies with the exclusion of this kind of study is the thing that I would find fault with, because what you would end up with is a big space in here where noise is doing something and you would have no idea what it is doing.

In other words, even if you, for example, put on curfews, if you stop trucks, if you—you know, the things that you can do ultimately perhaps, even in the most extreme sense, to cut down a certain amount of environmental noise, there is still chronic noise which is going to increase for other reasons in the environment. Now, what is going to happen is that—or what we are postulating, let's put it this way: we are all thinking about a problem and we are postulating that it is possible, as a result of that situation, that certain damage can occur on one or another level to a human being from this.

The question is: What ways do we go about assuming that this is a state we cannot relieve 30 msecs. from now or 30 years from now? What do we do to prevent serious damage from occurring, or to find some form of physiological therapy for that kind of damage, in a sense?

We cannot approach those problems without knowing what the mechanism is because you don't know where to hit at.

Dr. **Fidell.** Yes, but that would seem to be although not the least of our problems only one of our problems.

Dr. **Grenell.** That's right.

Dr. **Fidell.** And I can give a number of others that in my mind at least have greater salience. Let me see if I can clarify that somewhat. You talked in part on the effects of information overload on the brain and what that does to performance, excluding various inputs from the brain. Well, as a psychologist I can't even say what the effects of noise on performance are. You know, and I can cite you 10 different—

Dr. GRENELL. Well, I think you ought to go to work on that. (Laughter)

Dr. FIDELL. How about tomorrow morning?

Dr. GRENELL. That's fine.

Dr. FIDELL. Now, given that I can't even specify that for you, what good is it going to do me to know this other piece of information? I don't think that there would be any insights for it in that kind of information for the sorts of problems that the EPA is dealing with.

Dr. GRENELL. There might not be for you, but I would hope there would be for you.

Dr. MEYER. Well, if the Chair could—

Dr. FIDELL. I yield.

Dr. MEYER.—intrude into this interdisciplinary discussion. This proves one point with the exchange that is now being made, namely, this is a multivariant problem, there are different levels, and there are a multitude of disciplines involved in approaching the problem.

One of the interests of the Environmental Protection Agency is that if given the mandate by the Congress through legislation now pending, it would coordinate all Federal research relating to noise, then obviously it is going to stand on the knowledge of what the gaps are in other agency's responsibilities such as the Department of Health, Education, and Welfare. The Administrator of the Environmental Protection Agency is going to have under the acts now pending the responsibility for an in-depth appraisal of what knowledge is needed not only to deal with the specific action programs of the agency, but also the entire scope of the study of noise. So from that viewpoint, even if there was no immediate spinoff from an environmental action concept, there is a need to get into the record these concepts and these gaps which appear to the workers in the field.

Secondly, one can always fall into a bad trap, namely, that one assumes that only the results of basic research are of interest to basic researchers. All of us who have had any experience in the research division know that is the worst trap you can possibly fall into. Because after all, this creates the building blocks with which you move to advanced technology, advanced knowledge, and actual application. And some of us who have been in the field know that there is a science called bionomics, which is a translation of biological processes towards more directly environmental or hardware items. Extensive work has been done—as an example, so the record doesn't get cluttered up with scientific terminology too much—that this is attempting to find out how a bat flies at night, and how he operates, one of the biological phenomena which may be of use in other areas.

So some of the things that were presented in this paper do make a large contribution towards finding out some things which may be more directly applicable to other aspects of this problem.

Dr. FIDELL. That is the reductionist argument which says we should all be studying nuclear physics because after all water biological organisms may not—

Dr. **Meyer.** I don't want to cut you off, but I would say one thing about it, and that is: I could also turn this around and say that really everything that has been said in the field of biology as far as human physiology is concerned is that we ought to know more about cellular physiology. In fact, that is exactly the thrust of Dr. Grenell's paper. We are realizing how valuable it is to know more about what happens at the cellular level. At least that is the way I read your paper.

Dr. **Grenell.** That is right.

Dr. **Meyer.** And the biomechanics and bioelectronics are cellular physiological reactions, and unless I am reading you wrong—

Dr. **Grenell.** No, you are not, sir; you are not at all.

Dr. **Meyer.**—that is what you were talking about.

Any further comments?

Dr. **Fidell.** None at this point.

Dr. **Meyer.** Jim.

Dr. **Botsford.** No.

Dr. **Meyer.** Well, thank you very much for a very stimulating discussion. I think the information content here certainly was not to be classified as noise.

Dr. Bruce Welch, who is known to many of you, has headed up a number of investigations including a AAAS panel leading to a publication relating to some of the nonauditory physiological effects of noise. Dr. Welch, we will be very happy to hear from you at this time, sir.

## STATEMENT OF BRUCE L. WELCH, Ph.D., SCHOOL OF MEDICINE, THE JOHNS HOPKINS UNIVERSITY, BALTIMORE, Md.

Dr. **Welch.** Thank you very much, sir. It is a pleasure to be here, and it is extremely gratifying, I would like to say, to observe that the Environmental Protection Agency is now giving the attention to this subject that it very much deserves.

I am uncertain in what degree of complexity to deal here today in order to focus most clearly upon your particular interests. I think I wish to make the following main points: First, that when you change the environment of an organism, you change its physiological function, its basal level of physiological function, in many different ways. These alter, as a consequence, the susceptibility of the organism to disease, its potential for future behavioral and physiological responses of all kinds.

The second point would be that noise, like other environmental stimuli, has effects that are important not only at the time that the noise is in process and perceived, but has important sustained and long-lasting effects. And it is these that we perhaps would find the most important in a close analysis of the effects of noise upon health and upon behavior.

Thirdly, I would like to make the point that noise continually interacts with other environmental stimuli and stresses of all kinds. Its action is not a pure effect attributable to noise in and of itself, but an effect that interacts with the various stimuli to which the organism has previously been, is concurrently exposed to, and will in the future be exposed to in its environment.

The next point is that the stimuli which we call noise are never ignored. They may be attenuated but they are at all times monitored and subjected to high level analysis at the highest level of the brain. If we ignore or do not respond, we do it by choice although that choice may be unconsciously made. Therefore, the noise stimuli, the sound stimuli which we experience in our environment continually, invariably and continually do, in fact, have an effect, and because these effects are not only direct by specific neural pathways, but feed into collateral nonspecific pathways that are extremely important for the monitoring and control modulation of cardiovascular and various endocrine functions, their effect upon the body is continuous and all-pervasive.

The next point would be that the organism does not adapt. I will explore that further if you wish. The organism may change. It may change in such a way that in a particular environment, it is more capable of copying than it would be had that change not occurred. But the organism pays a price, and we must ask behaviorally and physiologically the cost that the organism pays, what, in fact, is the price? Are we willing to pay it?

We know that in biological evolutionary time, adaptation to one environment has very often diminished the capability of coping in a varied way with other environments. We might ask to what extent is the cost that we pay for adaptation to a high noise environment reducing our ability to cope in a more flexible way with other environments in which we should participate in terms of our health and recreation, our social interactions, and our psychological and mental well being.

The next point would be to clarify my stance by saying that I certainly do not think we can seek a completely quiet and sound-free environment free of all nonsignal impulses. There is an optimum. I don't know what the optimum is. Certainly it is not a completely silent environment, which we would find most annoying, but it is an environment that involves a certain amount and a certain variety of stimuli of all kinds.

On the other hand—another point—overstimulation is indeed possible, and it has adverse behavioral, social, and physiological consequences. Perhaps the most important point that I might make in a cursory survey of this subject would be to say, as Chelsea Leake said, in summarizing our symposium now almost 2 years ago: "In reality, I think that there exists at this time sufficient evidence for us to conclude that noise may and, in fact, does have harmful effects, behaviorally and physiologically. We do not need more research to show that. It would be desirable to have more research to clarify the mechanisms and details. We need, at this time, the judgment, the will, and the money to make our environment more pleasant and more healthful by eliminating unnecessary noise."

Now, in passing, I would like to repeat a few arguments that continually recur in discussions of this kind. I shall not go into detail in refuting them. I am willing to do so, if you ask.

The first is that the studies in animal models are not relevant to the understanding of human response to noise. This contention is based largely upon the fact that animals, being of a different species, are physiologically different, which no one would question in a broad sense, and upon the fact that much of the work that has been done with animals has been done with animals that are susceptible to so-called audiogenic seizures, to which men are seldom if ever susceptible.

However, I comment that our whole framework of neuroendocrine knowledge about the human body is based upon information derived from and continually referenced against, as we evaluate new drugs and new physiological systems, basic animal models. And I would comment in specific that while there are quite a few and indeed many categorical differences at the enzymatic level, immunological differences, and so forth, are quite common and to be expected between different species, different strains, and indeed individuals. The basic pattern of nonspecific response at the neuroendocrine level and in the cardiovascular system of all higher vertebrates is for all essential purposes the same. And it is with this major neuroendocrine system that we need to be most concerned when we talk about the behavioral and the physiological effects of noise. I think that, in fact, there is a great wealth of animal information existing which indicates that noise has adverse effects upon the reproductive system, the cardiovascular system, the neurological function of the body, and upon various other aspects of the animal physiology. And I would contend that this information is indeed referable to and relevant to the human situation.

The elements required in a reasonable consideration of the effects of noise upon health to establish an adverse effect, in fact, are:

1) Demonstrations of adverse effects in animal models confirmed by different investigators at different times, perhaps in different countries, confirmed in different strains and different species of animals, and this, in fact, has been shown.

2) Evidence that similar acute short-term effects are, in fact, observed in humans as they are observed in animals.

3) That in the long-term sense over a long period of time, when humans live in different environmental conditions, they develop physiological aberrations and impairments of health which might be reasonably predicted from these animal models. These studies, in fact, have been done, and these requirements have, in fact, been met.

The second argument that I would like to comment upon briefly is that the effects of noise are only psychological. The first thing I would say here is that only psychological perhaps may be a too hasty statement. If it were only psychological, it could be extremely important, because the majority of hospital beds in our country, the major portion of our money that goes into maintenance of health goes into the hospital beds that are occupied by people who are there for psychosomatic and mental health reasons, emotional disorders of one kind or another. Our major medical bill is related no longer to the infectious diseases in this country but far and yon by a higher proportion to diseases that have emotional, psychological origins.

To the extent that the effect of noise is "only psychological," I say it is extremely important and indeed perhaps more important than if it were predominantly physical in which case it would be easier to cope with. However, it is in no sense only psychological, as can be clearly demonstrated by the fact that animals respond behaviorally and physiologically as they have through evolutionary time evolved hereditary mechanisms that require them to respond when their cerebral cortises are not even present. The response physiologically, the response emotionally to noises of an abrupt and of a continuous steady state sort is a subcortical response primarily. It can be modified at the higher cortical level. But it is primarily one that does not require the cognity of a higher psychological processes at all.

The next argument that I would like to comment upon is that the effect of noise is largely related to its acceptability—acceptability in terms of the willingness of people to accept to put up with it, to endure it in their environment, or indeed their desire for it and their willingness to pay for it and to actively seek it.

As has been clearly shown in the case of the effect of noise upon hearing, noise that is sought, paid for, and indeed eventually enjoyed, can nevertheless be most damaging to the health. As is witnessed by the fact that in factories where people are exposed to adverse noise levels for a long period of time voluntarily for pay and indeed come over a period of years to ignore, in the sense that they are not consciously aware at every moment that the noise is, in fact, there, they nevertheless experience in a long-term sense the behavioral and the physiological consequences in impairment of their health, their social relations, and their mental welfare of the high level of noise exposure.

Another common argument is that if noise doesn't interfere with speech communication, perhaps it has no important effect at all. I think this is mildly utterly absurd as anyone who has tried to write a manuscript or has indeed tried to have a quiet evening to himself could attest that speech communication, the social-interaction process is indeed important—certainly not all-important—in the effects of noise.

Another point that might be made is that the intermittent noise exposure which we may experience is more important than long-term steady state noise exposure. There is a firm physiological and neurophysiological basis for this contention and we could talk about that in more detail.

Now, this has been a brief survey of major points, and a few comments on major arguments which continually recur which I thought needed to come to the fore very early this afternoon. I could, in fact, if you are interested in conserving time, stop at this point and yield to questions, or I can, if you choose, proceed with a moderately complex and detailed but straightforward argument for what I think is the most important and critical question relevant to the effects of noise, and that is the neurophysiological basis for my contention that the organism does not adapt, and that it is continually at all times affected in the various systems of the body by noise.

What is your desire, Mr. Chairman?

Dr. MEYER. Well, I think, because of the interest of the panel on the entire subject that I am going to ask the panel what they would like. We obviously want to get for the record your statement and I will ask the panel how do they feel.

(Discussion off the record.)

Dr. MEYER. What we would like to do now is stop for some questions and then we would like for you to go ahead and present that.

Dr. WELCH. Fine.

Dr. MEYER. How long is it, about 15 or 20 minutes after that?

Dr. WELCH. Perhaps 30. If you—

Dr. MEYER. Well, it is up to you.

Dr. WELCH. I will condense it as best as possible.

Dr. MEYER. If you would like to summarize it—but we are interested in this because there are honest differences of opinion on this, and I don't want to shut it off at all; I want to get it into the record and we would like to break right now though before you get into that and ask you some questions.

Dr. WELCH. I will, if you permit, at this time, include by reference for additional technical details that may not be covered here this morning the proceedings of the International Symposium on Physiological Effects of Noise, which was published by Plenum Press, New York.

Dr. MEYER. This will appear as a reference. It will not be printed with the transcript.

Dr. WELCH. Of course not.

Dr. MEYER. It then becomes a part of the public record and ultimately is a loss to that published. We will include it by reference, however.

All right, I will start off with Dr. Botsford, then.

Dr. BOTSFORD. These are some very interesting points you have brought up here. I wonder how much evidence we have that some of these effects actually take place in man. I am thinking of some of the industrial physicians I know who work with people who are exposed to noise at work don't see any effect other than hearing loss as a result of noise.

Now, can you enlighten me on that point?

Dr. WELCH. Well, the first thing I will do, Jim, is ask you a question. How closely have they looked? The last time we talked, I queried about inspection of health records of long term extents. Has this been done?

Dr. BOTSFORD. No, it hasn't. I think that our records are—it would have to be fairly obvious before they would be noticed in the industrial scene—the effects.

Dr. WELCH. Well, I think the main comment that I would make is that in this country, although the studies can fairly easily be done, they have not. And for that reason—let's back up even further. With statistical correlations taken in industrial settings or indeed in natural communities, you are never going to prove unequivocally and beyond contention that noise has adverse effects on man. It simply can't be done because the varied experiences over long periods of time to which man is exposed preclude the definition of a specific causal factor to the exclusion of all others.

That is why we have to have the two-pronged approach of well controlled animal studies which ethically can't be done with humans, and appropriate statistical models in human populations carried out in large studies.

Dr. Botsford. Is any effort being done to do the latter, that kind of study, that you know of?

Dr. Welch. I am sure the officials of the Environmental Protection Agency would know more about that than I.

I do hope that in this country such studies are planned. I think, however, I would be willing to say that they would probably be largely amplifying and confirming. I would make that prediction of the studies that have been now in other countries and repeated. I would hope that people at your company and in your profession would take the initiative to commit such studies in the remarkable natural laboratory that you have in your plants.

Dr. Fidell. I would like to comment on some of the arguments. In general, I liked them all. I like your rebuttal of the animal argument. I think that there can be little argument with that. Your comments about the effects are only psychological brings to mind, of course, what we mean by "only psychological."

I would like to amplify your statement that people will tolerate all kinds of noises which they know are harmful and point out that John Dougherty has already said they smoke cigarettes, too, and they know that is harmful. So people's behavior can't be taken as any indication of what is good for them in some sense. And then the other argument about speech communication also strikes me as a good one.

But the point I want to make continually here is I think those arguments are strong ones and there are better reasons for not doing some of the kinds of research that have been done.

I think some of the motivation for doing biologically-based research is of a strategic viewpoint which goes something of the following: We have not been able to stop noise pollution simply because it interferes with my enjoyment of life, the amenities of life because it may be interfering with psychological factors, but if we could demonstrate that noise was secretly eating up your liver, then we could probably get Congress to stop noise tomorrow morning, and on the basis of existing data, I don't think that there is a reasonable way for believing that there are such effects.

I think noise can affect the reproductive system, the endocrine system, but not disproportionately to its magnitude in its relation to other stressors, and I think viewing noise as one of many stresses is perhaps the only reasonable approach to this, and that it is not fruitful to look for some spectacular finding which will gain a lot of publicity, a lot of notoriety, and if it indeed existed would be instrumental in stopping noise pollution tomorrow morning.

Again, you know, I have general agreement with most of your arguments, with that one reservation, but if the ideas really define some spectacular medical finding, I don't think it is there, and I don't think there is reason for believing so based on what we know now.

Dr. **WELCH.** Well, I think that, in fact, there are many effects produced in the long-range which, if they could be produced immediately, you would indeed consider dramatic. I think that it is unfair to diminish our emphasis upon the importance of noise by saying that other stressors have important effects as well. I think we need to be concerned with all of the important stressors that affect our mental and physical health, and the fact that one and another and another is important and has deleterious effects by no means should detract from our attention and the emphasis that we place upon correcting any one of these.

Dr. **FIDELL.** Yes, but I agree perhaps more firmly than you do yourself with your contention that we don't need more research to show the effects. I really believe the effects are there. I am sure that noise is doing all sorts of unpleasant things physiologically to many organisms from animals to humans, and I don't think that more research is necessary to prove that. I think perhaps somehow if one could marshal all those data from the best of the cleanest experiments, the best designed experiments, and present that as a comprehensive package, that would convince any reasonable person that noise really does do terrible things to you, even if it is not eating up your liver.

I don't think that the emphasis is necessary to define something dramatic like that. I think the effects are dramatic enough as they are, and our knowledge of them, I think, should be adequate to convince most reasonable people of that.

I have nothing further to add.

Dr. **VON GIERKE.** Well, I think we all will agree with the general statements you made and with the outline of the various steps one has been taking and should take to study this problem more. I think you emphasized very nicely, I mean, what is the problem? And the problem is really a quantitative one. We know we need some kind of environmental stimuli to live, and we know overstimulation has harmful effects. But the question is: How do we find out best where is this medium range in which we can live and work and, again, pardon the expression, adapt to changing environment, because I am afraid you will never avoid that our environment stimuli will change to some extent, and I think we adapt to this, yes, at some cost, but as a total organism these costs can be paid in various ways. I mean some of the machines we have today which produce all of the noise, I mean they take physical labor from us and that is why man introduced them and more or less pays the price for some of the conveniences we get.

So this is a different problem. It is a quantitative one now to what environment do we want to adapt and do we want to accommodate ourselves in our living environment which we, I think, to a large extent, are free to choose.

In posing this question I will never forget one of our excellent researchers in our laboratory who studied the effect of vibratory stimuli on vasoconstriction and the cardiovascular system. He was working for 4 weeks to get a good method to measure the vasoconstriction in fingers and then to the vibratory stimuli on the arm. He just barely got a deflection of the needle, and then suddenly he got a very large deflection of the needle, and the reason was because one of the female laboratory workers walked through the room. And I mean to deflection from this was about 10 times larger than the deflection from the vibratory stimulus.

Dr. WELCH. And what, Henning, does that prove?

Dr. MEYER. Men are interested in girls.

Dr. WELCH. Right.

Dr. VON GIERKE. Well, I mean you could say, too, that looking at the girl is 10 times more dangerous and harmful than the vibratory stimulus. (Laughter)

Dr. WELCH. Only if your physiology was recently naive.

Dr. MEYER. Maybe from a psychological viewpoint.

Dr. VON GIERKE. So to come back to the three steps you outlined which one must take in studying the problem of animal studies to short-term human studies and to long-term human studies, I think there is very good evidence in animal studies that there are some effects. I think that quantitative mechanisms can be transferred to humans, as you indicated. I feel that quantitatively it will not tell us too much about what levels we should choose for man.

And here I ask the question if you would agree that subhuman primate studies would be one of the areas which have not been emphasized enough in past research.

Then, with respect to short-term effects on humans, I think a lot is known, and again perhaps this is not the most important area, at this point, to work on, but with respect to long-term effects on humans, I think very little good work has been done where you could base final conclusions on, and I think not very much is going on. So my main question is one of priority, that the highest priority, in my opinion, would be trying to get a handle on what can really be derived from long-term observation, and epidemiological studies in human populations; and second priority on subhuman primate studies.

Dr. WELCH. I would like to agree emphatically with your priorities of appropriate long-term and appropriately large-scale human statistical studies; and secondarily with the need for more detailed physiological responses which can't ethically be studied in humans and in higher primates. This is very important.

But I would like to respond even more directly and agree with you in your comment that all of this isn't going to tell us what noise levels we should establish. That has got to be done intuitively, and I would like to suggest much sooner than the time that waiting for research will afford.

I think we need good common sense and judgment, that the decision can be made now. I hope it is in process, as evidenced by these hearings, and I also hope that amplifying research will continue.

Dr. FIDELL. Could I?

Dr. MEYER. Yes.

Dr. FIDELL. I don't understand your point. You said the decisions have to be made intuitively now, but also intuitively in the future as to what price we are willing to pay for the costs of adaptation.

**Dr. Welch.** Well, I think the basis of the information that exists coupled with common sense will enable us to set reasonable guidelines, and I think those highly recommended in the Wilson Report of Great Britain are reasonable, and some that the U.S.S.R. has recommended seem quite reasonable on paper. I think we could set reasonable standards that would increase our comfort in living, consequently our health, without waiting for additional research.

**Dr. Fidell.** Then would the effects of the additional research just be to make small refinements in the levels we have chosen?

**Dr. Welch.** I think the additional research would be important and I do not wish to diminish the importance in helping us understand what the noise does to us, because we are not going to eliminate all of the noise no matter what rulings we make. And consequently because we know, then, what the noise does to us, it may help us: 1) prevent some of the adverse effects; and 2) correct them once they have occurred.

**Dr. von Gierke.** I would hope it would primarily tell us what price we should be willing to pay for noise control, and this is really—if you say we can set or should set reasonable levels now, I guess we all agree on this, but this is, to a large extent, an economic question; second degree probably an ethical question.

But in order to convince a whole society what price they should pay for it, I guess you have to know for what you are paying.

**Dr. Whitcomb.** I wanted to start with a statement that might be called "Let's hear it for stress," but after Henning's comment about girl-watchers, I am afraid to come out with this directly.

What I was going to say is that I am intuitively of the opinion that some stresses are good and some are bad. And stress in itself isn't necessarily a negative thing. I stress myself frequently in sports activities and things like that, and I would hate to be denied that, and I am not even sure that I would like to be denied an intense level rock and roll music, even if I knew I was paying a price—and I am not sure I would be.

One comment about the relevance of animal work. It is unfortunate that you missed one of the morning papers, because the discussion there following one of the papers would have been germane to what you were saying.

I think, in summary, that discussion stated more or less the following: that it is necessary to choose the animal carefully, and we were thinking about primates or animals for that level more than the frequent work with, say, rodents; and secondly, Henning made the comment that they should be presented with stimuli that are about equal in loudness to that normally encountered by humans. This would be in terms of dB above threshold, we will say, rather than equal in energy to what humans encounter, since some animals are more sensitive threshold-wise than humans.

Thirdly, we talked about the sound ideally being at an appropriate level and duration to that encountered by the bulk of people in our society, so that the research would be relevant and very directly relatable to the human situation.

**Dr. Eldredge.** Well, I think, Dr. Welch's comments are certainly pertinent with respect to the animal model. As I look at the literature, one of the apparent tools that goes along with this model is the use of something that is threatening, leads to a feeling of insecurity, or actual fear on the part of the animal colony, or some form of frustration, and, of course, this is not inappropriate to the human either.

Many of the worst noises either accompany other dangers—they are associated with powerful machinery which is not necessarily safe, and so on—or they lead to situations where activities are frustrating, and these—I think there is plenty of evidence to show that there is a real cost of adjustment—if you want to get around the adaptation and call it an adjustment—on the part of the organism to get around these things.

As Dr. Whitcomb was saying, maybe the cost of adjustment as such is not so bad except that I think the question comes up and I think the class of experiment that needs to be done now is to look at what is the value of rest from such cost of adjustment. Many of the experiments are done with exposures around the clock on really highly fear-inducing kinds of sounds, and these have relatively rapid effects working along with these stress responses. But the kind of information, I think, that would be very helpful to know is: what kinds of schedules of rest along with paying a cost of adjustment, which we are quite certain is there, would in fact allow one to get by without much penalty.

In other words, this is not all one way. There is the possibility of recovery, and it is in the absence of recovery that, I think, we see some of the worst effects even on the ear.

What is your reaction to this class of experiment; what might your view be?

Dr. **Welch.** I think I have no comment.

Dr. **Meyer.** One thing I would like to be sure that we do keep in focus. I certainly agree with one of the comments that Sanford Fidell made and that is: we have got enough information, and we have a problem with regard to noise. We certainly should not attempt to raise the specter of crisis unless it is really based on fact. And this, of course, is one of the things that I was interested in finding out. Where do we need to do more research?

What we are trying to do, in fact, is take a prospective, anticipatory role about noise as an environmental problem rather than allowing it to drift along until it does indeed become out of proportion.

The information we have been accumulating certainly indicates that a significant portion of the population of the United States is indeed exposed to noise impact of such a degree that it requires concern.

But before we proceed here further, I would like to ask a question, Dr. Welch. You made a statement which is often made that psychosomatic illnesses amount virtually to the major cost of illness in the United States. Do you have some information which shows the relative estimated cost of, quote, mental illness, mental disease, in relation to trauma, respiratory diseases, chronic degenerative diseases, in some sort of tabulated form that would bear out that statement for the record?

Dr. **Welch.** Data available in 1966 suggested 60 to 65 percent of total hospital beds, medical expenses, being related to the category of diseases that you mentioned.

Dr. **MEYER**. I have seen some of the information. I just wanted you to give me a literature reference to that later for the record, please, for that citation.

Dr. **WELCH**. Sure.

Dr. **MEYER**. Fine. Thank you.

At this point, before we go ahead, we will take a 5-minute—what we like to environmentally call—ecology break. Five minutes.

(Short recess.)

Dr. **MEYER**. We will now proceed after this brief recess.

Dr. Welch, if you would summarize for us the material that is contained in your other paper, the full paper will appear in the transcript and will be used by us in our studies.

We would appreciate it if we could forge ahead now because I know the panel, as has already been evidenced by questions to you, will probably have a few more questions and comments.

Dr. **WELCH**. All right, sir, I will apologize for—since I will do a lot of skipping here—being a bit skimpy.

I have noted that noise is commonly defined as "unwanted sound," but I will take the Handbook of Noise Control as being one of the more authoritative references which so defines it, but then it proceeds in that definition immediately to speak ambiguously on the very next page with the desirability of using "making noise" which then would not be undesirable obviously, to minimize the reactions to unwanted sound. And I think that there is sufficient evidence now to consider noise for our purpose to have a different definition, and that might be "audible sound which is harmful to human health," "health" being defined, as the World Health Organization defines it "as a state of complete physical, mental and social well being, and not merely the absence of disease or infirmity."

The overall intensity of audible sound in our environment is doubling, as you are aware about every 10 years, according to some estimates. Intensities and durations of sound considered hazardous to hearing in industry are frequently exceeded in many day-to-day recreational and living environments. And considerable evidence is now accumulated which indicates that noise may be harmful in other ways than mere impairment of hearing, and this evidence fortunately is gaining increasing recognition.

This noise, I would emphasize, or this audible sound may be harmful even when it is agreeable, even when it is wanted, and indeed even when it is wanted enough to be deliberately purchased; when it reduces the quality of sleep without entering consciousness it indeed has effects not only at the time but effects that are reflected the next day in behavioral performance and physiological responses. Even when the sound during sleep that is experienced is not strong enough or effective enough actually to cause waking, and it has effects when it is tolerated for so long that it becomes the environmental norm and thereby largely goes unnoticed.

There are psychological effects of noise, and it should be quite obvious that the psychological effects can be extremely important when they contribute to anxiety or emotional problems of one kind or another. Therefore, I will largely avoid those and focus more definitively rather upon the general characteristics of noise as a contributor to physiological and psychological consequences of overstimulation, and try to stay away from the rather obvious ground of emotional consequences when one objects to noise and the adverse effects that are so related.

I am not going to be concerned here with the effects of explosive blasts which are well known. I want to be concerned rather with the effects of noise of a relatively nonspecific sort, noise of a characteristic or characteristics that are experienced in the everyday environment.

Before proceeding, however, I will comment briefly that psychological factors are important in response to noise, and briefly a few things might be said about that.

I hope you will ask Dr. Glass of Rockefeller University to include a commentary on his research in the published proceedings. He has important things to say. Among these are that an unpredictable noise, as others have said, is more important in producing adverse consequences than predictable noise. People are less affected if they have a feeling that they can control or that they can predict.

He has evidence that noise lures tolerance to frustration, particularly if the noise is unpredictable, and I think this is important if we view the undocumented contentions that appear from time to time in the public press which suggest that noise has an influence upon aggressive behavior.

There are a few suggestions in the animal literature that noise can in some instances trigger aggression. I think this is not a major point, however, for emphasis.

Psychologically we know that the Chinese in times past—and perhaps many other people, I would suspect—have explicitly used noise as torture, with the consequence of brain washing, and prior to that severe emotional and personality distortion.

There was a report submitted at the American Psychiatric Association meeting in Washington, D.C. this past fall indicating impaired performance efficiency in various tasks on the day following noise levels experienced at night, which were not, in fact, loud enough to actually cause waking. Waking was caused, as the Kryter studies would suggest, and Lucas, in older people; not necessarily so in the younger people. This had a more or less intermediate effect in those of middle age. But the noise definitely caused physiological effects in terms of either waking or in terms of decreased deep sleep of the Stage 3 and 4 type, noise even of only 90, 85 dB, and the consequence of such experience during the night even after repetitive long-term exposure was impaired performance proficiency in various measures on the following day.

Noise aids attention, as you well know, and I shan't dwell on that, particularly in the short-term. But it has the consequence of increased channeling of thought and increased effort to focus, a diminishing capability of flexible opportunistic response which may be indeed very vital to coping with, in an appropriate way, many aspects of our complex modern environment.

Much can be said about interruption and distraction anxiety. There is a great body of psychological theory that relates. Clearly we have a limited number of channels that can be loaded with information. When these channels are in competition and overloaded, we may experience indeed real situations, and there is strong reason to suspect, in which noise prolonged either of a sustained or intermittent type can cause anxiety and many would conceive that anxiety of a chronic sort is the first step to certain types of mental illness.

The important part, I think, of talking about the adaptive mechanisms of the body are their failure to adapt, in fact, and about the sustained long-term effects and the establishment of different basal levels and balances of metabolic functions must focus upon neuroregulation. And considerable evidence exists which indicates that general neuroregulatory and endocrine responses reflect in a nonspecific way the level of environmental stimulation, as it varies on a continuum from sensory deprivation to stimulus overloading.

The central nervous system of vertebrates contains fundamentally two broad classes of neurons that are motor neurons and neurons of the so-called "internuncial net" of which the brainstem reticular formation, which you have heard about already is a part, but it is a recipient continually of virtually the entire sensory influx from the environment.

Environmental stimuli are essential for the maintenance of consciousness and the waking state. Stimuli received by all sensory modalities, in addition to their specific effects, make collateral and sometimes direct contributions to the nonspecific activation of descending and ascending fibers of the brainstem reticular formation. Some of the ascending fibers pass directly to the cerebral cortex and some project upon the nonspecific midline and intralaminar nuclei and nucleus reticularis of the thalamus, and elsewere, to activate neurons that project diffusely upon all areas of the cerebral cortex. These projections to the cerebral cortex lower thresholds for excitation in specific sensory areas and thereby contribute to a general increase in the level of central nervous activation or arousal.

Concomitant with and as a consequence of activation of the brainstem and thalamic reticular formation, neurons originating in the cortex and also in the medulla oblongata are activated which, in servo-fashion, modulate and restrain the reticular activating system and raise the threshold for its further activation. Negative feedback control is not instantaneous, however. Indeed, over a considerable range increases in the level of stimulation continue to cause increases, although progressively smaller increases, in the level of arousal and reticular activation.

Neurons originating in the cerebral cortez also have important activating effects upon brainstem and thalamic nuclei of the reticular activating system, both directly and also indirectly through connections with limbic areas, the hypothalamus, the caudate, and other structures. Through these connections, cognitive processes and emotions exert powerful influences upon the reticular formation and make important contributions, both phasic and tonic, to its level of activity.

An important point, then, having said in effect with reference to the fact that we do have nonspecific activation all the time by all types of stimuli, which is modulated by feedback from the cerebral cortex, an important point is that the reticular formation is tonically active, and its level of activity reflects, in an integrated fashion, the level of environmental stimulation. Sound, or indeed electrical stimulation of the midbrain reticular formation by implanted electrodes, acts similarly to cause concomitant behavioral arousal and electroencephalographic activation. Auditory stimuli are particularly important, and are distinctly more important than visual stimuii, in maintaining tonic activity of the reticular activating system.

Although the level of reticular activation and the tonus cerebrale are ultimately dependent upon environmental stimuli, they obviously are not directly driven by them in an immediate temporal sense. Activation persists long after the initiating stimuli have passed. Indeed this ability to sustain activation is clearly a prerequisite for the relative behavioral independence of environment that we observe. However, it also means that loud sound only intermittently repeated may cause a relatively high level of reticular activation and cortical arousal to be maintained for relatively long periods of time.

Of course, the response to auditory stimuli is not such a simple story of nonspecific activation and its negative feedback modulation as these comments imply. An exception is seen in the fact that very low frequency stimuli have powerful soporific effects that are antagonistic to the arousing influences of the reticular activation system. By recruitment, low frequency stimuli entrain and synchronize waves of electrical activity in great masses of the brain with pulses originating in nonspecific midline nuclei of the thalamus in a manner similar to that which actually occurs naturally in normal slow wave sleep. These tonic inhibitory influences seem to be regulated by the orbitofrontal cortex of the brain.

Another exception lies in the fact that the auditory system, like other sensory systems, is particularly responsive to change. Hence, a transcient increase in the firing of auditory neurons may be produced by the termination of a sound as well as by its inception. Some neurons in the auditory system respond to stimulus onset with a high rate of impulse discharge, quickly cease firing, remain silent while the stimulus is continued, and discharge a second burst of impulses when the stimulus stops. However, in a much larger number of neurons, the rate of firing declines to a lower level of activity shortly after the initial high-frequency discharge and is then tonically maintained during very long. periods of continued stimulation. The proportion of neurons that maintain their activity without ceasing activity during continuous stimulation is relatively greater, as would be expected, in lower parts than higher parts of the brain. It is these lower parts that are important in autonomic and in integral control.

Now, the body is aroused in its various functions concomitant with activation of the reticular formation. This formation controls and integrates tonic and phasic influences that are continually exerted upon spinal outflow from the lower brainstem to modulate cardiovascular and circulatory, gastrointestinal, respiratory, somatomotor, pancreatic, and other essential peripheral functions. Sound influences these functions by direct and collateral connections of auditory pathways with the reticular formation and with pontile, medullary, and spinal motor systems and also, less directly, via its influence upon higher order psychological processes which, in turn, influence the reticular formation.

Although neuronal connections of the hypothalamus with the lower brainstem are multisynaptic and consequently have been traced only as far as the mesencephalic reticular formation thus far, it seems certain that influences exerted by the hypothalamus upon these and other autonomic functions, including the release of catecholamines from the adrenal medulla, act through these routes.

The hypothalamus, which has been referred to by Sherrington as "the head ganglion of the autonomic nervous system", is the controlling and integrating structure for neuroendocrine function. Neurons from more caudal portions of the reticular formation massively invade the hypothalamus, particularly its lateral portions, and thereby exert important tonic influences upon it, and auditory stimuli have been shown to evoke responses in cells in various of its regions.

Primary sensory areas of the cerebral cortex make inputs via association areas to the entorhinal area from which arise the major cortical fibers to the hippocampus, and the hippocampal formation integrates and channels these influences from widely spaced neocortical areas down through the septum to exert important tonic influences again upon the hypothalamus.

So from every direction we have an evidence for, at a neurophysiological level, sustained reflexes of a long-lasting tonic sort of noise, even at a nonspecific level, where that noise has no emotionally disturbing or psychological effects, although the latter could indeed intensify the effects if the noise is not produced.

However, although the limbic system receives nonreciprocated inputs from the frontal cortex, it receives its major input from the brainstem reticular formation (via the medial forebrain bundle, the mammillary peduncle, and the dorsal longitudinal fasciculus), and its major neuronal discharges, (including those of the hippocampus, amygdala, and septal nuclei) are into the hypothalamus (via the medial forebrain bundle, the stria terminalis, and the precommissural fornix), and back into the reticular formation in the medial region of the midbrain tegmentum.

In effect, then, the hypothalamus functions as a nodal way-station in both the ascending and descending pathways of this so-called "limbic-midbrain circuit." The functional state of the hypothalamus is inseparably related—and this is a major point—to the pattern of neural activity in this circuit as a whole and, in many important ways, is intimately and ultimately determined by the activity of the brainstem reticular formation and thereby by the stimulus environment.

The pituitary, the "master gland of the body," is attached to the base of the hypothalamus, moving in sequence here, and is controlled by it. The hormonal secretions of the anterior pituitary (adrenocorticotrophic hormone, growth hormone, thyrotrophic hormone, luteinizing hormone, follicle stimulating hormone, and prolactin), the hormonal secretions of the posterior pituitary (oxytocin and vasopressin), and all of the forementioned physiological functions are altered by electrical stimulation of the brainstem, limbic and hypothalamic areas and, through the mediation of the brain, by environmental stimuli, including and more specifically noise.

The primary, secondary, tertiary, and higher-order consequences of these effects are all-pervasive: literally every function of the body is affected.

Comprehensive references are available, and I shan't go into extensive detail on the nature of these effects here.

Particularly relevant to the following portions of my comments are detailed considerations of central nervous function and hormonal influences upon cardiovascular function, neuroendocrine and environmental influences upon reproductive function, and psychological influences upon the endocrines. These are available and could be integrated.

Overall consideration of these various factors in terms of integrative response to environment suggests that emphasis should be given to the following important points: 1) that the environmental stimuli exert tonic influences—continual influences—upon physiological functions, and cause different basal levels of various physiological functions to be maintained in different stimulus environments; 2) that various physiological functions are continually influenced by common and routine ambient influences and changes in the "normal" stimulus environment; 3) that stimulus-induced alterations of physiological functions and their sequale persist long after the initiating stimuli have passed; and 4) that the effect of an environmental stimulus upon a particular hormonal secretion or other physiological function is importantly influenced by the extant level of activation, by the time elapsed since last stimulation, by the activity of other interacting physiological functions, and by any other factor that influences the "set" of the system; 5) that environmental stimuli alter not only various physiological functions but their pattern of activity in time and their pattern of activity relative to one another.

This point has been particularly emphasized by workers with regard to the endocrine secretions. This emphasis is appropriate for the evidence is very strong that many physical and mental illnesses result from altered balance, integration, and organization of normal bodily functions.

We are not going to talk here about a categorical stress response related to an up or down secretion of the adrenal cortex, the adrenal medulla, or any other individual gland. We are talking about more subtle and more complex phenomena.

In terms of the adaptive, so much for basal level of function and its invariant consequence to environmental stimulation. Let's talk a bit about the fact that we don't adapt. We must, in talking about this, consider the so-called "novelty" reflex; when a sound is first experienced or has not been heard for some time, it elicits an involuntary "novelty" or "orientation" reflex. This may involve only an immediate slight increase in arousal followed by a mental shift of attention to the sound. More often, one reflexly tenses the neck muscles and turns the eyes and head in the direction of the sound. Concomitantly, the threshold for auditory response drops by 4 to 10 decibels. There is always a generalized increase in the level of activation of the reticular activating system, the generalized thalamocortical projection system, and the cerebral cortex. Within limits the increase in arousal is proportional to the intensity of the sound, provided that other characteristics of the sound remain the same. If the sound is subsequently repeated within a short period of time, the orienting reflex may indeed habituate—this is not the same as adapting—i.e., it gradually wanes, and after 10 to 30 repetitions of the sound, the overt manifestations of the orientation reflex cease.

If an appreciable amount of time passes between repetitions of a sound, however, dishabituation will gradually occur and repetition of the sound will again evoke an orientation reflex. Habituation normally does not occur if attention is directed to a sound or if a sound that has special significance, either positive or negative. Sounds of near threshold intensity hints the importance of even low levels of noise in some cases. Sounds of near threshold intensity d[illegible] easily habituate, probably because of the difficulty of discriminating between them and assessing their significance. Sounds of moderate intensity may not habituate but, depending upon [illegible] attitude towards them and their duration and character, they may elicit either positive or adverse emotional responses, either of which may further increase the level of arousal; if their repetition is prolonged, a defensive response is likely.

During habituation to a given sound, thresholds for response to other sounds are often lowered. Sounds which differ only slightly from a habituated sound may elicit an orientation reflex and concomitantly cause dishabituation of the original sound, the repetition of which will then again evoke an orientation reflex which may again habituate. But our environmental stimuli of an auditory source are complex, and pure habituation seldom if ever occurs.

Even after habituation has ostensibly occurred, unattended auditory stimuli continue at all times to have effects in both cortical and subcortical areas of the brain. Evidence for this includes the following: 1) Signals evoked in specific auditory pathways reach the cerebral cortex about twice as fast as the nonspecific impulses that are concomitantly evoked by collateral influences upon the reticular activating system, and when the subconscious decision is made not to orient to a sound corticofugal fibers actively restrain—actively—the nonspecific reticular activation from spreading to higher areas of the brain. This is not surprising for it would be inimical to survival through evolutionary time to decrease alterness to danger by excluding unattended stimuli from high level analysis.

2) Information concerning unattended stimuli is stored in memory and can, in fact, be recalled.

3) In animals that are habituated to sound, there are, nevertheless, dramatic changes in the chemistry of the brain.

4) While the orienting response to an acoustic stimulus is habituating, there may be no change, or actually a concomitant increase, in the amplitude of the auditory evoked potential in the cortex and in the medial geniculate body. The evoked responses to sound that are recorded from the auditory cortex or the medial geniculate body wane with repeated stimulation, but they do not disappear.

5) Afferent neurons of the auditory pathways and, hence, neurons of the reticular activating system, always respond to auditory stimuli. Evoked potentials in auditory nuclei peripheral to the medial geniculate do not habituate to repeated or sustained sound, or if so only to a small degree. For all practical purposes, the response of these nuclei is invariant irrespective of behavioral state. In some experiments in which cats were exposed to a click of about 70 dB every 10 seconds around the clock, day in and day out, 10 to 14 days passed before there was a reduction in amplitude of the evoked response. A "fairly loud" click presented to a cat in a quiet room produced little or no habituation when presented continuously for 8 to 10 hours and "very little" habituation when presented 100 times per day for 10 to 15 days. While behavioral habituation is occurring, the diffuse surface-positive secondary response on the cerebral cortex that is attributable to nonspecific reticular activation may become relatively small and inconspicuous but it does not disappear. Clearly, the reticular activating system and the various structures that it influences continue to be affected by sound even after behavioral habituation has occurred. They merely are not so greatly affected as they would be if there had been no subjective decision to "ignore."

Now, consider perhaps what is less important for us than the routine "novelty" response that is associated with the on-going ambient level of environment, but nevertheless important in some cases, and that is startle. A great deal is said about startle in consideration of the effects of noise, although much more generally should be said, in fact, about the more subtle aspects of our auditory environment.

Any sudden sound that surprises will elicit a startle reflex whether it surprises or not. The cochlear branch of the auditory nerve enters the lower brainstem laterally at the anterior edge of the medulla oblongata just below the pons, and signals produced in this nerve by high intensity impulse sound cause massive discharges to all higher levels of the brain and directly over reticulospinal routes to the periphery, largely overriding any existing cortical inhibition. In its fullest manifestation, the overt characteristics of the startle response include blinking of the eyes and an abrupt forward movement of the head, opening of the mouth, raising and drawing of the shoulders forward, abduction of the upper arms, flexing the fingers, and so forth, perhaps "freezing."

In its simpler form where the sound is anticipated and the person is well-controlled, as with a good marksman, the startle reflex may overtly be only an eye blink and a slight tensing of the muscles. Startle is largely independent of the frequency of the startling sound.

The magnitude of startle is greatly increased when fear is conditionally associated with a loud impulse sound; this fear-induced increase in startle may habituate if the sound is frequently repeated. However, the nonconditioned component of the startle reflex does not completely habituate. In some animal experiments, the startle reflex has been evoked many hundreds of times without its abolition, often under conditions where it is truly remarkable that the animals did not cease responding from general fatigue.

For instance, rats that were exposed to 30 msec. pulses of broadband random sound with a rise-decay time to 2.5 msec. and an intensity of 119 dB at one minute intervals over a period of approximately 11 hours, for a total of 675 startle stimuli, were still responding when the experiment ended with a startle reflex that was 30 percent of the maximum observed. Rats exposed 10 times per day at intervals of 30 to 60 seconds to a 112 dB sound of 6,000 Hz., having a rise time of about 3 msec., still startled on the ninth day of exposure at about 25 percent of the maximum magnitude of startle observed.

In another study, rats that were exposed daily to an impulse sound of 72 dB—and that is really not very loud—centered at 400 Hertz each 5 seconds for approximately 2 hours, for a total of about 1,500 impulses per day, ceased to make overt muscular responses that were readily apparent to an observer only after 9 days, while mice did not cease to respond even after 20 days.

Clearly, complete habituation of the startle reflex, even to impulse sound of moderate intensity, is not readily achieved. If an intense sound is repeated many times, the magnitude of startle diminishes but a startle reflex continues to be evoked by the sound. Indeed, prior to the diminution of the startle reflex that may occur in succeeding daily sessions of exposure to loud impulse sound, sensitization often occurs and the startle reflex is exaggerated for a few days. When a degree of habituation has occurred to even severe sound exposures in laboratory animals and stimulation is discontinued, dishabituation occurs within 24 to 48 hours, and the magnitude of startle that is elicited by reinstatement of the sound is commonly 60 to 80 percent of the maximum magnitude previously observed.

In humans, different acute physiological effects of startle habituate to different degrees. For all practical purposes, however, the available evidence supports the contention of Landis and Hunt, which is often misquoted, that the startle response to intense impulse sound does not habituate. An intense impulse sound, no matter how often it is heard, continues to have abrupt effects upon the activating systems of the brain.

Other environmental stimuli may modify the auditory startle reflex. For example, when the startle of rats to 1,000 Hertz tone of 110 dB intensity had habituated to about 35 percent of the maximum magnitude of startle observed, a one-second exposure to a 20 Hertz flashing light increased the magnitude of startle that was elicited by the immediately following repetition of the auditory stimulus to about 75 percent of the observed maximum. Similarly, a barely audible pulse of broad-band sound (25 dB) that preceded a high-intensity impulse sound of broadband random noise of 135 dB by about 5 msec. facilitated startle, as reflected by a decreased response latency (there were no changes in startle amplitude). The reduction in latency increased with increasing prepulse intensity. When the same barely audible prepulse was given with a lead time of about 100 msec., the startle elicited by the intense sound was inhibited, as reflected by decreased response amplitude and increased response latency. Apparently the brain is sensitized to startle for perhaps 10 msec. following the barely audible prepulse and then becomes relatively refractory for a few hundred msec.

The modification of auditory startle in rats by sounds that are themselves too weak to produce an overt response suggested to some workers that auditory startle is not an all-or-nothing response—this is important for our consideration here—it is not an all-or-none responre dependent solely upon a sudden intense sound, but rather the extreme reaction on a continuum of responses to sound—that the brain mechanisms responsible for startle are continually activated by all environmental sounds even though they may not be intense enough to cause overt startle.

A background of steady random sound as low as 50 dB greatly facilitates the evocation of startle by intense impulse sound, and the degree of facilitation increases as the level of background sound is increased. Rats which seldom if ever respond to an impulse sound with startle in a quiet environment consistently exhibit massive startle reactions to the same impulse sound when a steady background signal is present. These affects of background sound are largely independent of frequency and do not appear to habituate even after long periods of continued exposure.

That sound has important tonic and phasic influences upon the primitive areas of the brain which do not require modulation by the higher centers has been further emphasized by the results of lesion studies. As has been mentioned briefly today, ablation of the auditory cortex impairs frequency discrimination (at least for tones of short duration) and impairs the ability to localize sound in space more or less in proportion to the extent of the lesion, but intensity thresholds are little changed and intensity discrimination is wholly retained. Animals from which the auditory cortex has been completely removed retain the ability to learn or relearn conditioned auditory responses. Frontal cortical lesions, destruction of the cerebral cortex, or thalamic or brainstem lesions rostral to the trapezoid body do not abolish the response to sound but, to the contrary, by preventing normal cortical inhibition they result in exaggerated startle and novelty reflexes and in a complete loss of the ability to habituate to sound. Clearly, the less discriminative responses to sound are not high-order psychological phenomena.

A point that has not received adequate attention, I think, in our rather cursory studies of human response to sound is the fact that individuals respond very differently. There are many conditions in which normal habituation to sound does not occur. This commonly reflects the absence of normal inhibition of the reticular activating system of the cerebral cortex. In such individuals, peripheral physiological functions do not have normal protection thereby from abrupt influences of sudden environmental sounds. Habituation is slow or impaired and reactivity to sound exaggerated or prolonged in senile dementia, in Tay-Sachs babies, in some patients that are schizophrenic, neurotic, or anxious, and in some children suffering from hyperkinesis, autism, or other brain damage. The novelty or startle reflex to sound varies with time of day, with development of age, and is affected by drugs.

There are wide differences in habituation to sound between different strains and species and between individuals. Individual human neonates differ widely in reactivity to startling sound, and many of these differences seem quite stable over time. Genetic factors are obviously important. However, the foetus is fully capable of responding to sound by 6 months of age, and it is reasonable to expect that some differences in auditory reactivity of newborns may be due to a difference in their intra-uterine auditory experience.

In recent years, the human neonate in the newborn nursery has become a primary research subject for studies of physiological and behavioral habituation to sound. The possibility cannot be discounted that these studies, which in some instances employ prolonged intermittent exposure to 90 115 dB sounds, may contribute to the development of later individual differences in physiological and behavioral response—some undesirable, in these instances.

I would offer this, then, as evidence that for reasonable neurological grounds we could argue to a minimal adaptive response to the sustained high level basal functions of high level noise.

The cardiovascular effects of noise merit special emphasis. The evidence is strong that environmental noise of intensities that are commonly experienced in our day-to-day surroundings may contribute to the development of cardiovascular disease. Points of evidence include the following: Surveys made in several countries have shown that people who work in industries where they are exposed to high levels of noise for long periods of time have a higher incidence of hypertension than normal. Within these industries, persons who are exposed to relatively high levels of noise have a higher incidence of hypertension than those who are exposed to lower levels of noise.

Second, it is clearly demonstrated that noise can cause hypertension and enlargement of the heart in experimental animals of several species.

Third, short-term noise exposures produce cardiovascular responses in humans that are similar to those that are produced by short-term noise exposures in animals.

Dr. MEYER. And could you summarize the key points of the rest of your paper?

Dr. WELCH. Very well.

I think the other points would include here a modest amount of detail on reproductive hormonal balance, sleep, neurological effects, of which I particularly wish to mention the fact that animals which are not susceptible to audiogenic seizures can be made so by exposure to a single high intensity noise stimulus so that subsequent to that time, they are henceforth subject to audiogenic seizures by auditory stimuli.

This may relate to direct effects upon development of mechanisms in the brain which can influence the sensitivity of an individual to noise through a substantial portion of his life. This does not require psychological factors because the effect can be produced when the noise exposure is initially made, while the animal is even under ether anaesthesia. It is more fundamental an effect than that.

Noise alters drug responses which is stressed at some detail. The concept of adaptation is nebulous. We should not focus greatly upon that.

As I have done on one previous occasion, I would like to close by focusing your attention for the future not merely upon auditory stimuli that can be heard but upon subsonic sound. Whatever definition we are concerned with so far today, it has been sound that we can hear. In the future, we should be concerned also with the effects of infra-sound, sound of very low frequencies that we can't hear, particularly in certain industrial environments and in residential communities surrounding.

The lower the frequency of a sound, the further it carries and the greater its penetrating power. A giant infra-sound whistle that is being used experimentally in Marseilles, France, has a frequency of only 29 cycles per second (just below the level of hearing) and a range of 30 miles. Infra-sound of even weak intensities can penetrate houses, the walls of normal soundproofed rooms, and the tissues of the body. It is reasonable to expect that infra-sound may act directly upon the nerves and the endocrine glands and affect our health and our emotions. It is produced by many motors and industrial engines, and in the future attention should be directed to identifying sources of infra-sound, its distribution in our manmade environment, and the nature of its effects upon us.

I apologize to you for the detail, but in a sense you led me on here. I do think that it is, in answering questions related to the reality of physiological effects of noise upon the body, ultimately necessary to offer solid neurophysiological evidence.

Dr. MEYER. Before I ask the panel if they have any additional questions, would you comment briefly on a comparison between the central nervous system response that you have described and that characterized by other stimuli? You mentioned one, the flashing light, which, of course, has always been used in comparisons of light and sound effects. But would you comment on some of the other—the differences, if any, between the response mechanisms and your rather extensive review, which is very important—and I wouldn't denigrate the importance of it—it is just that we do have to be out of here at a certain time.

Dr. WELCH. Absolutely.

Dr. MEYER. Would you mind commenting—are there significant differences between these response mechanisms that you have described and those of other environmental stimuli? I guess that's the easiest way for me to state the question.

Dr. Welch. Well, I think the major environmental stimuli that we are concerned with are the visual and the auditory in this context, and the nature of the nonspecific effects—and I have tried to focus primarily upon them—is similar. But the quantitative difference may be very great, and it certainly does appear in evolutionary time that we have developed a greater susceptibility to startle activation by sound than by, let's say, light. And we do know that in a cerebral corticate, for instance, all of the characteristic symptoms of fear and rage can be evoked by a shrill high-pitched sound, but by no other type of stimulus. So it is a basic protective mechanism, in a sense, to alert to danger in the environment that operates at the subcortical level and which we have inherited, which is perhaps more important in a quantitative sense in influencing us than it would be abrupt flashes of light.

Dr. Meyer. I will start on the right. Dr. Botsford?

Dr. Botsford. No questions.

Dr. Fidell. I guess my conclusion is that there is a fundamental difference between what constitutes a medical belief and scientific proof. No one is going to refute Dr. Welch's grasp of physiology, but there is just what appears to me is a large gap here, a non sequitur, if you will. Explanation is not description. A treatise on the functional organization of the nervous system does not constitute proof to me of the effects of noise on the body, and I wouldn't want that sort of proof anyway. I would rather have some experimental data.

I understand you left out the technical—the detailed parts—but there is something fundamentally missing, which I guess is preventing communication between different ways of looking at things. I guess I have no further comments.

Dr. Welch. Well, we can include and refer to specific studies showing specific degrees of blood pressure elevation, and that sort of thing. But these are available and included by reference.

Dr. von Gierke. Well, I can only go back to what I have said before. It is a matter of degree, and unless you go to really quantitative data and examples, I must agree with Dr. Fidell, it doesn't prove a thing one way or another. We know it can be harmful, but unless we know at what level it is harmful, it doesn't help us very much.

Just for the record, I would like to say that we have programs on the effect of ultra-sound—inaudible ultra-sound—on the human body and on hearing since many years, and we have since a few years a program on the effect of inaudible infra-sound on the human body. NASA and our laboratory started in this area about 4 or 5 years ago.

Dr. Meyer. Any other questions or comments?

Well, thank you very much, Dr. Welch. I am most appreciative of getting this into the record because we want to balance the many diverse views on the subject, and your entire material, of course, will appear in the record.

There is one thing I would like to ask you, in conclusion, and that is you mentioned several study references that we ought to take a look at. If you would furnish me those references, the literature citations which you gave, so that we can avail ourselves of them, and so it will appear in the record.

Thank you very much, sir.

(The above mentioned references are as follows:)

The number of beds in psychiatric hospitals is 545,502 as compared with 1,065,509 in non-psychiatric hospitals. (Source: National Center for Health Statistics, "Hospitals—A County and Metropolitan Area Data Book," Rockville, Md., 1970. U.S. Public Health Service Publication No. 2043, Table 1, page 5).

Many of the latter are occupied by persons suffering from emotional and psychosomatic disorders. Thanks to modern psychopharmacology, a larger proportion of the mentally ill are now treated on an out-patient basis than ever before and, hence, do not occupy hospital beds.

A maximum of $6 billion is spent on mental illness in the U.S. annually, as compared with about $60 billion for all health care. (Source: "Insurance Coverage for Mental Illness", page 19, Author: Follmann, J. F., 1970. Publisher: American Management Association, New York, 1970).

The total estimated annual cost of mental illness in this country, including that attributable to loss of work, is about $21 billion. (Source: "Facts on the Major Killing and Crippling Diseases in the U.S.", 1971; Compiled by National Health Education Committee, Inc., New York, 1971, pp. 1–28).

It is estimated that one person in ten in the United States is suffering from some form of mental illness of varying degrees of severity. Twenty million persons are said to need psychiatric treatment. (Source: "Facts on the Major Killing and Crippling Diseases in the U.S.", 1971; Compiled by National Health Education Committee, Inc., New York, 1971, pp. 1–28).

Dr. David C. Glass, Research Center for Human Relations, New York University, 4 Washington Place, 6th floor, New York, N.Y., 10003, is doing research on the behavioral effects of noise, which is of interest to you.

Dr. **Welch**. My apology for the long time—for all of the time that I took.

Dr. **Meyer**. No, we invited you to come. We wanted to hear what you said. We just had to ask you to speed it up just a little bit.

(The documents submitted by Dr. Welch follow in their entirety.)

## PHYSIOLOGICAL AND PSYCHOLOGICAL EFFECTS OF NOISE

Noise I define as audible sound that may be harmful to human health. Health is defined as the World Health Organization defines it, as "a state of complete physical, mental, and social well-being, and not merely the absence of disease or infirmity".

The overall intensity of audible sound in our environment is approximately doubling every ten years. Intensities and durations of sound that are considered hazardous to hearing in industry are frequently exceeded in many day-to-day recreation and living environments.

In at least one instance, significant hearing loss among people living near a civil airport (Santa Monica Airport, California) has been authoritatively attributed to jet noise occurring during run-up periods of about 3 min. 5 times per day.

Considerable evidence has now accumulated which indicates that noise may be harmful in ways other than mere impairment of hearing. Audible sound may be harmful even when it is agreeable and even when it is wanted, even when it is wanted enough to be deliberately purchased; when it reduces the quality of sleep without entering consciousness deeply enough to cause waking; and when it is tolerated for so long that it becomes the environmental norm and largely goes unnoticed.

In the following comments, I will review those aspects of integrative neurophysiology which suggest that noise may be expected to have important allpervasive influences upon physiological and psychological functions, subsequently, I will summarize available evidence that noise in fact has important adverse effects. Focus will not be upon the harmful effects of noise that derive from its cognitive or subconscious association with danger or with unpleasant past or possible future events, but upon the harm to health that may be attributed to the more general characteristics of noise as a contributor to the physiological and psychological consequences of overstimulation. Hearing impairment has been amply treated by others. The effects of explosive blast are well known and will not be discussed. These comments are concerned with the effects of noise as experienced in the everyday environment.

## NEUROREGULATION

I have previously published in considerable detail some important general neuroregulatory and endocrine responses that reflect the level of environmental stimulation as it varies on a continuum from sensory deprivation to stimulus overloading (1).

The central nervous system of vertebrates contains two broad classes of neurons: motor neurons and neurons of the great "internuncial net" of which the brainstem reticular formation, the recipient of virtually the entire sensory influx from the environment, is the major functional part.

Environmental stimuli are essential for the maintenance of consciousness and the waking state. Stimuli received by all sensory modalites, in addition to their specific effects, make collateral and sometimes direct contributions to the nonspecific activation of descending and ascending fibers of the brainstem reticular formation. Some of the ascending fibers of the brainstem reticular formation pass directly to the cerebral cortex and some project upon the "nonspecific" midline and intralaminar nuclei and nucleus reticularis of the thalamus (and also posterolateral association nuclei, especially the pulvinar) to activate neurons that project diffusely upon all areas of the cerebral cortex. These projections to the cerebral cortex lower thresholds for excitation in specific sensory areas and thereby contribute to a general increase in the level of central nervous activation or arousal.

Concomitant with and as a consequence of activation of the brainstem and thalamic reticular formation, neurons originating in the cortex and also in the medulla oblongata are activated which, in servo-fashion, modulate and restrain the reticular activating system and raise the threshold for its further activation. Negative feed-back control is not instantaneous, however. Over a considerable range increases in the level of stimulation continues to cause increases, albeit progressively smaller increases, in the level of arousal and reticular activation.

Neurons originating in the cerebral cortex also have important *activating* effects upon brainstem and thalamic nuclei of the reticular activating system, both directly and also indirectly through connections with limbic areas, the hypothalamus, the caudate, and other structures. Through these connections, cognitive processes and emotions exert powerful influences upon the reticular formation and make important contributions, both phasic and tonic, to its level of activity.

The reticular formation is *tonically active*, and its tonic level of activity reflects, in an integrated fashion, the level of environmental stimulation. Sound, or electrical stimulation of the midbrain reticular formation by implanted electrodes, act similarly to cause concomitant behavioral arousal and electroencephalographic (EEG) activation. Auditory stimuli are particularly important, and are distinctly more important than visual stimuli, in maintaining tonic activity of the reticular activating system.

Although the level of reticular activation and the *tonus cérébrale* are ultimately dependent upon environmental stimuli, they obviously are not directly driven by them in an immediate temporal sense. Activation persists long after the initiating stimuli have passed. This ability to sustain activation is clearly a prerequisite for the relative behavioral independence of environment that we observe. However, it also means that loud sound only intermittently repeated may cause a relatively high level of reticular activation and cortical arousal to be *maintained* for relatively long periods of time.

Of course, the response to auditory stimuli is not such a simple story of nonspecific activation and its negative feedback modulation as the above comments imply. One exception is seen in the fact that very low frequency stimuli (about 3 Hz) have powerful soporific effects that are antagonistic to the arousing influences of the reticular activation system. By recruitment, low frequency stimuli entrain and synchronize waves of electrical activity in great masses of the brain with pulses originating in nonspecific midline nuclei of the thalamus in a manner similar to that which occurs in normal slow wave sleep; these tonic inhibitory influences seem to be regulated by the orbitofrontal cortex.

Another exception lies in the fact that the auditory system, like other sensory systems, is particularly responsive to *change*. Hence, a transient increase in the firing of auditory neurons may be produced by the termination of a sound as well as by its inception. Some neurons in the auditory system respond to stimulus onset with a high rate of impulse discharge, quickly cease firing, remain silent while the stimulus is continued, and discharge a second burst of impulses when the stimulus stops. However, in a much larger number of neurons, the rate of firing declines to a lower level of activity shortly after the initial high-frequency discharge and is then *tonically maintained* during long periods of continued stimulation. The proportion of neurons that maintain their activity during continuous stimulation is relatively greater in lower than in higher parts of the brain.

### PHYSIOLOGICAL REGULATION

The body is aroused concomitant with activation of the reticular formation. The reticular activating system controls and integrates tonic and phasic influences that are continually exerted upon spinal outflow from the lower brainstem to modulate cardiovascular and circulatory, gastrointestinal, respiratory, somatomotor, pancreatic, and other essential peripheral functions. Sound influences these functions by direct and collateral connections of auditory pathways with the reticular formation and with pontile, medullary, and spinal motor systems and also, less directly, via its influence upon higher order psychological processes which, in turn, influence the reticular formation. Although neuronal connections of the hypothalamus with the lower brainstem are multisynaptic and have been traced only as far as the mesencephalic reticular formation, it seems certain that influences exerted by the hypothalamus upon these and other autonomic functions, including the release of catecholamines from the adrenal medulla, act through these routes.

The hypothalamus, which Sherrington referred to as "the head ganglion of the autonomic system", is the controlling and integrating structure for neuroendocrine function. Neurons from more caudal portions of the reticular formation massively invade the hypothalamus, particularly its lateral portions, and exert important tonic influences upon it, and auditory stimuli have been shown to evoke responses in cells in various of its regions. Primary sensory areas of the cerebral make inputs via association areas to the entorhinal area from which arise the major cortical fibers to the hippocampus, and the hippocampal formation integrates and channels [illegible]ences from widely spaced neocortical areas down through the septum to exert important tonic influences upon the hypothalamus. However, although the limbic system receives non-reciprocated inputs from the frontal cortex, it receives its major input from the brainstem reticular formation (via the medial forebrain bundle, the mammillary peduncle, and the dorsal longitudinal fasciculus), and its major neuronal discharges (including those of the hippocampus, amygdala, and septal nuclei) are into the hypothalamus (via the medial forebrain bundle, the stria terminalis, and the precommissural fornix) and back into the reticular formation in the medial region of the midbrain tegmentum. In effect, the hypothalamus functions as a nodal way-station in both the ascending and descending pathways of this "limbic-midbrain circuit." The functional state of the hypothalamus is inseparably related to the pattern of neural activity in this circuit as a whole and, in many important ways, is intimately—and ultimately—determined by the activity of the brainstem reticular formation and by the stimulus environment.

The pituitary, the "master gland of the body," is attached to the base of the hypothalamus and is controlled by it. The hormonal secretions of the anterior pituitary (adrenocorticotrophic hormone, growth horomone, thyrotrophic hormone, luteinizing hormone, follicle stimulating hormone, and prolactin), the hormonal secretions of the posterior pituitary (oxytocin and vasopressin), and all of the aforementioned physiological functions are altered by electrical stimulation of brainstem, limbic or hypothalamic areas and, through the mediation of the brain, by environmental stimuli. The primary, secondary, tertiary, and higher-order consequences of these effects are all-pervasive: literally every function of the body is affected. In the space available here, it would be impossible to review the extensive evidence and the detailed mechanisms for these effects. Comprehensive references are available. Particularly relevant to the following portions of this article are detailed considerations of central nervous and hormonal influences upon cardiovascular function, neuroendocrine and environmental influences upon reproduction, and psychological influences upon the endocrines.

Overall consideration of these various factors in terms of integrative response to environment suggests that emphasis should be given the following important points: (i) that environmental stimuli exert *tonic influences* upon physiological functions and cause *different basal levels* of various physiological functions to be *maintained* in different stimulus environments; (ii) that various physiological functions are continually influenced by common and routine ambient influences and changes in the *"normal" stimulus environment;* (iii) that stimulus-induced alterations of physiological functions and their sequale *persist* long after the initiating stimuli have passed; (iv) that the effect of an environmental stimulus upon a particular hormonal secretion or other physiological function is importantly influenced by the existing level of activation, by the time elapsed since stimulation, by the activity of other interacting physiological functions, and by any other factor that influences the "set" of the system; (v) that environmental stimuli alter not only various physiological functions but their *pattern* of activity in time and their pattern of activity relative to one another. The latter point has been particularly emphasized by Mason (2) with regard to the endocrine secretions. His emphasis is appropriate, for the evidence is very strong that many physical and mental illnesses result from altered balance, integration, and organization of normal bodily functions.

## EVIDENCE THAT WE DO NOT ADAPT TO NOISE

### NOVELTY REFLEX

When a sound is first experienced or has not been heard for some time, it elicits an *involuntary* "novelty" or "orientation" reflex. This may involve only an immediate slight increase in arousal followed by a mental shift of attention to the sound. More often, one *reflexly* tenses the neck muscles and turns the eyes and head in the direction of the sound. Concomitantly, the threshold for auditory response drops 4–10 dB. There is always a generalized increase in the level of activation of the reticular activating system, the generalized thalamo-cortical projection system, and the cerebral cortex. Within limits the increase in arousal is proportional to the intensity of the sound, provided that other characteristics of the sound remain the same. If the sound is subsequently repeated within a short period of time, the orienting reflex may habituate, i.e. it gradually wanes and after 10–30 repetitions of the sound the overt manifestations of the orientation reflex cease.

If an appreciable amount of time passes between repetitions of a sound, dishabituation will gradually occur and repetition of the sound will again evoke an orientation reflex. Habituation normally does not occur if attention is directed to a sound or if a sound that has special significance, either positive or negative. Sounds of near threshold intensity do not easily habituate, probably because of the difficulty of discriminating between them and assessing their significance. Sounds of moderate intensity may not habituate but, depending upon attitude towards them and their duration and character, they may elicit either positive or adversive emotional responses, either of which may further increase the level of arousal; if their repetition is prolonged, a defensive response is likely.

During habituation to a given sound, thresholds for response to other sounds are often lowered. Sounds which differ only slightly from a habituated sound may elicit an orientation reflex and concomitantly cause dishabituation of the original sound, the repetition of which will then again evoke an orientation reflex which may again habituate.

Even after habituation has ostensibly occurred, *unattended auditory stimuli continue to have effects in both cortical and subcortical areas of the brain.* Evidence for this includes the following: (i) Signals evoked in specific auditory pathways reach the cerebral cortex about twice as fast as the nonspecific impulses that are concomitantly evoked by collateral influences upon the reticular activating system, and when the subconscious decision is made not to orient to a sound corticofugal fibers actively restrain the nonspecific reticular activation from spreading to higher areas of the brain. This is not surprising for it would be inimical to survival through evolutionary time to decrease alertness to danger by excluding unattended stimuli from high level analysis. (ii) Information concerning unattended stimuli is stored in memory and can be recalled. (iii) In animals that are habituated to sound, there are dramatic changes in the chemistry of the grain. (iv) While the orienting response to an acoustic stimulus is habituating there may be no change, or actually a concomitant increase, in the amplitude of the auditory evoked potential in the cortex and in the medial geniculate body. The evoked responses to sound that are recorded from the auditory cortex or the medial geniculate body wane with repeated stimulation, but they do not disappear. (v) Afferent neurons of the auditory pathways and, hence, neurons of the reticular activating system, *always* respond to auditory stimuli. Evoked potentials in auditory nuclei peripheral to the medial geniculate do not habituate to repeated or sustained sound, or if so only to a small degree. For all practical purposes, the response of these nuclei is invariant irrespective of behavioral state. In some experiments in which cats were exposed to a click of about 70 dB every 10 sec around the clock, 10–14 days passed before there was reduction in amplitude of the evoked response. A "fairly loud" click presented to a cat in a quiet room produced little or no habituation when presented continuously for 8–10 hours and "very little" habituation when presented 100 times per day for 10–15 days. While behavioral habituation is occurring, the diffuse surface-positive secondary response on the cerebral cortex that is attributable to nonspecific reticular activation may become relatively small and inconspicuous but it does not disappear. Clearly, the reticular activating system and the various structures that it influences continue to be affected by sound even after behavioral habituation has occurred. They merely are not so greatly affected as they would be if there had been no decision to "ignore."

### STARTLE

Any sudden sound that surprises will elicit a startle reflex. Any *loud* impulse sound will elicit a startle reflex whether it surprises or not. The cochlear branch of the auditory nerve enters the lower brainstem laterally at the anterior edge of the medulla oblongata just below the pons, and signals produced in this nerve by high intensity impulse sound cause massive discharges to all higher levels of the brain and directly over reticulospinal routes to the periphery, largely overriding any existing cortical inhibition. In its fullest manifestation, the overt characteristics of the startle response include blinking of the eyes and an abrupt forward movement of the head, opening of the mouth, raising and drawing of the shoulders forward, abduction of the upper arms, flexing the fingers, forward movement of the trunk, contraction of the abdomen, bending the knees, and sometimes "freezing." In its simpler form where the sound is anticipated and the person is well-controlled, as with a good marksman, the startle reflex may overtly be only an eye blink and a slight tensing of the muscles. Startle is largely independent of the frequency of the startling sound.

The magnitude of startle is greatly increased when fear is conditionally associated with the loud impulse sound; this fear-induced increase in startle may habituate if the sound is frequently repeated. However, the nonconditioned component of the startle reflex does not completely habituate. In some animal experiments, the startle reflex has been evoked many hundreds of times without its abolition, often under conditions where it is truly remarkable that the animals did not cease responding from general fatigue.

For instance, rats that were exposed to 30 msec pulses of broadband random sound with a rise-decay time of 2.5 msec and an intensity of 119 dB at one minute intervals over a period of approximately 11 hours, for a total of 675 startle stimuli, were still responding when the experiment ended with a startle reflex that was 30 per cent of the maximum startle observed. Rats exposed 10 times per day at intervals of 30–60 sec to an 112 dB sound of 6000 Hz, having a rise time of about 3 msec, still startled on the ninth day of exposure at about 25 per cent of the maximum magnitude of startle observed. In another study, rats that were exposed daily to an impulse sound of 72 dB centered at 400 Hz each 5 sec for approximately 2 hours, for a total of about 1500 impulses per day, ceased to make overt muscular responses that were readily apparent to an observer only after nine days, while mice did not cease to respond even after 20 days. Clearly, complete habituation of the startle reflex, even to impulse sound of moderate intensity, is not readily achieved. If an intense sound is repeated many times the magnitude of startle diminishes but a startle reflex continues to be evoked by the sound. Indeed, prior to the diminuition of the startle reflex that may occur in succeeding daily sessions of exposure to loud impulse sound, *sensitization* often occurs and the startle reflex is exaggerated for a few days. When a degree of habituation has occurred to even severe sound exposures in laboratory animals and stimulation is discontinued, dishabituation occurs within 24–48 hours and the magnitude of startle that is elicited by reinstatement of the sound is commonly 60–80 per cent of the maximum magnitude previously observed. In humans, different acute physiological effects of startle habituate to different degrees. For all practical purposes, however, the available evidence supports the contention of Landis and Hunt that the startle response to intense impulse sound does not habituate. An intense impulse sound, no matter how often it is heard, continues to have abrupt effects upon the activating systems of the brain.

Other environmental stimuli may modify the auditory startle reflex. For example, then the startle of rats to a 1000 Hz tone of 110 dB intensity had habituated to about 35 per cent of the maximum magnitude of startle observed, a one-second exposure to a 20 Hz flashing light increased the magnitude of startle that was elicited by the immediately following repetition of the auditory stimulus to about 75 per cent of the observed maximum. Similarly, a barely audible pulse of broad-band random sound (35 dB) that preceded a high-intensity impulse sound (broad band random, 135 dB) by about 5 msec facilitated startle, as reflected by a decreased response latency (there was no change in startle amplitude). The reduction in latency increased with increasing prepulse intensity. When the same barely audible prepulse was given with a lead time of about 100 msec, the startle elicited by the intense sound was inhibited, as reflected by decreased response amplitude and increased response latency. Apparently the brain is sensitized to startle for perhaps 10 msec following the barely audible prepulse and then becomes relatively refractory for several hundred msec. (The latter phenomenon may be the same as Bekesy's "backward inhibition. The modification of auditory startle in rats by sounds that are themselves too weak to produce an overt response suggested to Hoffman and colleagues that acoustic startle is not an all-or-nothing response dependent solely upon a sudden intense sound, but rather the extreme reaction on a continuum of responses to sound—*that the brain mechanisms responsible for startle are continually activated by all environmental sounds even though they may not be intense enough to cause overt startle*. A background of steady random sound as low as 50 dB greatly facilitates the evokation of startle by intense impulse sound, and the degree of facilitation increases as the level of background sound is increased. Rats which seldom if ever respond to an impulse sound with startle in a quiet environment consistently exhibit massive startle reactions to the same impulse sound when a steady background signal is present. These effects of background sound are largely independent of frequency and do not appear to habituate even after long periods of continued exposure.

### LESION STUDIES

That *sound has important tonic and phasic effects upon the primative areas of the brain which do not require mediation by the higher centers* has been further emphasized by the results of lesion studies. Ablation of the auditory cortex impairs frequency discrimination (at least for tones of short duration) and impairs the ability to localize sound in space more or less in proportion to the extent of the lesion, but intensity thresholds are little changed and intensity discrimination is retained. Animals from which the auditory cortex has been completely removed retain the ability to learn or re-learn conditioned auditory responses. Frontal cortical lesions, destruction of the cerebral cortex, or thalamic or brainstem lesions rostral to the trapezoid body do not abolish the response to sound but, to the contrary, by preventing normal cortical inhibition they result in exaggerated startle and novelty reflexes and in a complete loss of the ability to habituate to sound. Clearly, the less discriminative responses to sound are not high-order psychological phenomena.

### INDIVIDUAL DIFFERENCES

There are many conditions in which normal habituation to sound does not occur. This commonly reflects the absence of normal inhibition of the reticular activating system by the cerebral cortex. In such individuals, peripheral physiological functions do not have normal protection from abrupt influences of sudden environmental sounds. Habituation is slow or impaired and reactivity to sound evaggerated or prolonged in senile dementia, in Tay-Sachs babies, in some patients that are schizophrenic, neurotic, or anxious, and in some children suffering from hyperkinesis, autism, or other brain damage. The novelty or startle reflex to sound varies with time of day, with developmental age, and is affected by drugs. There are wide differences in habituation to sound between different strains and species and between individuals. Individual human neonates differ widely in reactivity to startling sound, and many of these differences seem quite stable over time. Genetic factors are obviously important. However, the foetus is fully capable of responding to sound by six months of age, and it is reasonable to expect that some differences in auditory reactivity of newborns may be due to differences in their intra-uterine auditory experience. In recent years, the human neonate in the newborn nursery has become a primary research subject for studies of physiological and behavioral habituation to sound. The possibility cannot be discounted that these studies, which in some instances employ prolonged intermittent exposure to closely-spaced 90–115 dB sounds, may contribute to the development of later individual differences in physiological and behavioral response to sound.

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2. Mason, W. A., 1968. Organization of psychoactive meahanisms. Psychosomatic Medicine 30:, No. 5, Part II: 565–808.

The above comments were intended to demonstrate that there are solid neurophysiological reasons for believing that noise has important all-pervasive influences upon the body, and for believing that, in a physiological sense, the body does not adapt to noise.

Following, in summary fashion, is evidence that noise has adverse effects upon bodily functions. For detailed documentation refer to *Physiologival Effects of Noise*, B. L. Welch and A. S. Welch (Editors), Plenum Press, New York, 1970.

*The Cardiovascular System.* The cardiovascular effects of noise merit special emphasis. The evidence is strong that environmental noise, of intensities that are commonly experienced in our day-to-day surroundings, may contribute to the development of cardiovascular disease. Surveys made in several countries have shown that people who work in industries where they are exposed to high levels of noise for long periods of time have a higher incidence of hypertension than normal. Within these industries, persons who are exposed to relatively high levels of noise have a higher incidence of hypertension than those who are exposed to lower levels of noise.

It has been clearly demonstrated that noise can cause hypertension and enlargement of the heart in experimental animals of several species.

Short-term noise exposures produce cardiovascular responses in humans that are similar to those that are produced by short-term noise exposures in animals.

Since the neurological and hormonal functions of humans and of other higher animals are similar (Indeed, most of our medical knowledge is based upon the assumption of this similarity!), it is reasonable to expect that noise may cause some forms of hypertension in man. *The evidence for this is sufficiently strong that the burden of proof is now upon those who contend that it cannot do such harm.* The cardiovascular system can be affected by noise even when a "temporary threshhold shift" in hearing acuity is negligible or does not occur at all. The ear is never affected by noise without the cardiovascular system responding as well.

*The Reproductive System.* Laboratories in five countries (USA, Israel, Hungary, Japan, USSR) agree that noise may influence the course of pregnancy, result in increased absorption of embryos, decrease the number of viable young that are born, and increase the number of congenital malformations of various kinds. Noise stimulates the ovary to accelerate the development and release of eggs, but the blood supply to the eggs and, later, to the developing embryo is poorer than normal. This may account for the relatively poor development of foetuses in pregnant animals exposed to noise. For obvious reasons, the experimental work to which I refer has been done only in animals, not in man. However, sound has been used to trigger the release of eggs from the ovary in humans, and this is even being studied as a possible treatment for problems of infertility. It is reasonable to expect that the other effects of noise upon the reproductive system which have been observed in experimental animals also occur in man.

*Balance of the Hormonal System.* Noise alters the secretion of all hormones that have been carefully studied, both in man and in animals. Many mental and physical illnesses are influenced by altered hormonal balance, including susceptibility to infectious disease. It has, in fact, been shown that experimental animals are more susceptible to bacterial and to certain viral infections when they are stressed by noise. It has been shown that body growth can be impaired in experimental animals by exposure to noise, and some statistical studies of human populations living near airports in Japan suggest that noise may have at least a modest ability to impair the growth of young humans.

Noise causes marked and prolonged elevation of plasma triglycerides, and in cholesterol-fed animals it results in higher blood cholesterol and more frequent and more severe atherosclerosis than in similarly fed control animals.

*Sleep.* Interruption and prevention of sleep is an important but not thoroughly documented effect of noise pollution.

A few particularly relevant clinical studies that have not been recognized by those concerned with the physiological effects of noise in this country are abstracted as follows:

Andriukin, A. A., 1961. Influence of sound stimulation on the development of hypertension. Cor et Vasa 3: 285–293.

A total of 1232 subjects, 676 men and 556 women, were studied in industrial workshops where noise levels of 93, 103 and 120 decibels prevailed. Hypertension was approximately twice as frequent as in quieter factories elsewhere in the same city. The incidence of morbidity from hypertension increased with increase in ambient noise level. The frequency of hypertension increases with length of time of employment under noisy conditions.

Jirkova, H. and B. Kremarova, 1965. Investigations of the effect of noise on the general health of workers in large engineering factories: attempt at evaluation. Pracovni Lekarstvi 17: 147–148.

969 factory workers studied. Results show higher incidence of hypertension, peptic ulcer, impaired hearing and subjective complaints in people exposed for long periods to noisy surroundings.

Shatalov, N. N., Saitanov, A. O. and Glotov, K. V., 1962. On the state of cardiovascular system under conditions involving exposures to the action of permanent noise.

300 factory workers daily exposed to 85–120 decibels, medium to high

frequency, were examined. There was increased lability of arterial pressure and a tendency towards decreased intrventricular conductivity. After stress and at the end of the work day alternations of the electrocardiographic T-wave were suggestive of decreased functional capability of the heart. Workers exposed to the most intense noise, 114–120 decibels) demonstrated these changes more frequently and to a greater extent.

Ponomarenko, I. I., 1966. The effect of constant high-frequency industrial noise on certain physiological functions in adolescents. Hygiene and Sanitation 31: 188–193.

625 observations were made on adolescents working under industrial noise levels of 85 decibels, 1000-2000 Hz maxium frequency. In the course of the working day there was an increase in diastolic and a decrease in systolic blood pressure; a decrease in vascular tone pulse pressure, pulse rate and systolic index; and increase in reflex response time to light and sound; and a deterioration in the capacity for mental work.

Andrukovich, A. I., 1965. Effect of industrial noise and weaving factories on the arterial pressure of operators. Gig. Tr. Prof. Zabol. 9: 39–42.

Blood pressure was measures over a three year period in 546 female operators of winding and weaving machines, an average of 5.4 measures per person. The operators experienced high frequency impulse noise of 90–102 decibels. It was suggested that the noise had a hypertensive effect, as judged by comparisons with other workers of the same age in the same geographical area.

Storozhchuk, K. V., 1966. Effect of noise on the nervous system of preschool children. Hygiene and Sanitation 31: 50–54.

52 children were studied in detail in two residential homes for preschool children (6-6.5 years of age, 28 girls and 24 boys). Those subjected to a relatively high background noise level 65–75 decibels) as compared with 40–55 decibels) exhibited longer latencies of response to light and sound stimuli, and the acquisition of clerical skills was slower.

## ADAPTATION

I would like to comment again very briefly upon the concept of adaptation. In my view, adjustment to an environment in such manner as to permit optimal function *in that environment* constitutes adaptation. But this involves bending ourselves to fit that environment. Optimal function in a particular extreme environment may differ greatly from the optimal function of which we are genetically capable in an environment that is truly optimal. In an extreme environment, optimal function may mean mere survival. Always, it involves accepting penalties psychologically, socially, and in terms of our physical health. When we adapt we cannot necessarily assume that we are then "alright," or that we are then "just as well off" as we were before adaptation was required. We must ask, "What is the price that we must pay? Is it desirable to pay that price? Is it necessary for us to have to pay that price?" One of the most effective adaptations to some noise environments would be to go deaf!

Finally, I would like to mention a subject that may be of great interest in the future. Today we are talking about noise—"audible sound that may be harmful to the health." Whatever the definition, we are concerned with the effects of sound that we can *hear*. In the future we will need to also be concerned with the effects of infra-sound, sound of very low frequencies that we cannot hear. The lower the frequency of a sound, the further it carries and the greater its penetrating power. A giant infra-sound whistle that is being used experimentally in Marseilles, France, has a frequency of only 20 cycles per second (which is just below the level of our hearing) and a range of 20 miles. Infra-sound of even very weak intensities can penetrate houses, the walls of normal sound-proofed rooms, and the tissues of the body. It is reasonable to expect that infra-sound may act directly upon the nerves and the endocrine glands and affect our health, and our emotions. Infra-sound is produced by many motors and industrial engines. In the future, attention must be directed to the sources of infra-sound, its distribution in our mad-made environment, and its effects upon our bodies and our minds. Dr. von Gierke mentions that studies in this area are underway at Wright Patterson Air Force Base. However, from the studies that have emerged from these laboratories over the past 10–15 years, I judge that the studies now in progress are not likely to be sufficiently inclusive to answer all of the questions, or even the major questions, in this area that should be asked.

Again, I wish to say how pleased I am that these hearings on the Physiological and Psychological Effects of Noise are being held, and to express my gratitude for being invited to participate in them. However, I have three relevant concerns, and they are as follows:

1. I am disappointed to note that our "expert" panel which is charged with providing documented summary and analysis of the material presented consists largely of persons who have competence in areas other than that in which they are trying to judge and who either (i) have a long history of committment to the idea that noise has no harmful effects unless it impairs hearing or (ii) a long history of passively evading the evidence that it may have other adverse effects. You need advice not merely from people who purport to know about noise, but from experts who know about the various functions of the body. A logical place to go for this expert advice would be to the various professional medical societies. If these societies were provided with copies of available papers on the effects of noise and with adequate funds, they could give you the best available analysis of the importance of the effects of noise upon physiological and psychological function.
2. To my knowledge no effort has yet been made to compile copies of technical papers in the foreign literature on the physiological effects of noise in one place and translate them into the English language. Until this is done, hearings such as these are largely a waste of time, for attempts are being made to reach judgements on matters without access to, or evaluation of, the major body of relevant evidence that has been published.
3. When you ask scientists to come here to testify from various parts of the nation, as you have done, without offering to pay their expenses, you are not designing the most favorable situation in which to obtain carefully researched, synthesized, well-thought-out advice. Scientific advice of the sort that you are seeking does not grow free and spontaneously of its own accord. It is developed slowly, painfully and expensively. It requires time, library access, secretarial assistance, xerox facilities, etc. One of my colleagues who is also testifying before you today is a distinguished neurophysiologist who, until recently, was funded by NASA for many years to conduct basic research that is immediately relevant to your interests. A few months ago, his research support was abruptly terminated and he has lost his entire staff and all means of research support. He is testifying at no cost to you. His expenses are being met by his academic department which, itself, is fighting a marginal battle for survival. The kind of competence that you are seeking is not being financed and developed in the United States today, and it will not be available for helping to choose options for action in the future unless funding practices for basic research are materially changed.

Dr. **Meyer**. At this point, then, I would like to ask W. Dixon Ward, who may have some slightly different views on this subject, which we will be also anxious to hear.

Dr. Ward.

## STATEMENT OF DR. W. DIXON WARD, HEARING RESEARCH LABORATORY, UNIVERSITY OF MINNESOTA, MINNEAPOLIS, MINN.

Dr. **Ward**. Thank you.

The first part of what I say will be a prepared statement that was thrown together by the Committee on Noise As a Public Health Hazard of the American Speech and Hearing Association, and we got it at least semi-approved by the Executive Council of that group because they raised no strong objections. So I will have to read this essentially as it is, and then I will discuss some of these extra-auditory effects at greater lengths.

The American Speech and Hearing Association is concerned mainly with two of the several aspects of the noise problem: its effect on hearing and on the process of speech communication. As a result of concentrated field and laboratory research conducted during the past 20 years, the intensity level at which continuous noises become dangerous to hearing when exposure is for 8 hours a day, 5 days a week, over a period of many years, is reasonably well established. Negligible risk exists until the level exceeds 80 dB(A); the risk becomes significant at 90 dB(A), and hearing losses are nearly inevitably produced if the level approaches 100 dB(A). However, if either the noise itself or a given individual's personal exposure is intermittent, then considerably higher levels can be tolerated. This accounts for the lower-than-expected incidence of hearing loss in miners, foresters, and rock-and-roll musicians, for example, all of whom are exposed to levels of 110 dB(A) and even greater. By the same token, however, if daily exposures are greater than 8 hours, then even lower levels than 80 dB(A) can be barely tolerated. If, therefore, one is speaking of the hazard of a source of noise, then any steady noise above 70 dB(A) may be considered "hazardous," although one must keep in mind that extremely long uninterrupted exposures to this minimum level—days or weeks—are required before a real hazard to the particular ear concerned can be considered to exist.

However, it is not possible to make a similar simple statement about impulsive noises such as gunfire, hammering, firecrackers, and drop-forge impacts—the decibel level at which impulse noise becomes hazardous depends on the duration of the pulse. Long-duration single pulses ("thumps") or pulses generated in reverberant surroundings (like an indoor shooting gallery) may be hazardous at a peak level of 140 dB at the ear, while very short-duration pulses ("clicks" or "cracks" are quite safe at 160 dB, as in the case of the ordinary cap pistol (not the Italian cap guns that shoot individual pellet-shaped caps). Those are hazardous.

Now, the following section was contributed by Dr. Jerry Tobias, a member of our Committee. Dr. Tobias is Chief, Communication Processes, Civil Aeromedical Institute of the FAA Aeronautical Center in Oklahoma City.

Dr. Tobias says: "In discussions of noise and its effects on people, some environments are not often considered. For example, the internal environments of noise-producing vehicles have only recently been investigated. Light aircraft of the sort that are used for crop dusting are almost universally in excess of safe levels. These planes are flown for as much as 14 hours a day. Cockpit noise in other light aircraft varies, depending upon which plane is being tested, from 85 to 100 dB(A); the average is about 95. Air-transport planes have cockpit noise levels varying from about 70 to 95 dB(A); the average is approximately 85 dB(A). Cabin noises in the larger planes cover similar ranges, although the noise sources may change as one moves from the front to the rear of a cabin. The people exposed to such noises include not only pilots, stewardesses, instructors, and flight engineers, but also passengers, many of whom fly frequently.

"For most of us, the noise to be found inside automobiles can be neglected as a public health hazard. However, some professional drivers are commonly over-exposed. New standards are being promoted by the Federal Highway Administration for acceptable noise levels in the cabs and tractors of trucks in interstate commerce. However, the implementation of these standards is a long way off, and many trucks now in operation will continue to be too noisy even after new standards go into effect." That is the end of Dr. Tobias' section.

We are interested, as you see, not only in industrial noises and impulses but those that we encounter in everyday life as well. Although within-the-home appliances seldom if ever involve levels and exposure patterns that reach the hazardous point, plenty of hazards lurk just outside the door. Few machines using internal combustion engines are safe. In particular, chain saws, snowmobiles, power mowers, and trail bikes are usually well above the 90 dB(A) mark, often above 100 dB(A), so ear protection or, when practical, noise reduction, is strongly recommended. The loss of hearing that still results every year from exposure to sporting arms at rifle and shoftgun ranges is particularly deplorable, because the wearing of adequate and comfortable ear protection against the firing of others is not only prudent but will also improve the accuracy of shooting as well.

The second major area in which our concern lies is that of communication. The next two paragraphs were prepared by another member of our Committee, Dr. John C. Webster, a specialist on speech communication at the Naval Electronics Laboratory Center in San Diego.

He says: "In addition to the potential damaging effects of noise on hearing, the other universal concomitant of noise is its effect on speaking and listening. As the ambient noise increases above about 50 dB(A) most normal hearing people increase their vocal output at a rate between 3 and 5 dB per 10-dB increase in noise. The rate of vocal effort increase depends primarily on the speaker's task. If it is imperative he be understood, he approaches the 5 dB/10 dB rate. In casual social situations the rate is closer to 3 dB/10 dB. (See Lane, H., B. Tranal and C. Sisson, J. Acoust. Soc. Am. 47, 618–624, 1970.)

"Since the increase in vocal output does not keep pace with the increase in noise, people must and do get closer together in increasing levels of noise to make themselves understood. The relations among noise levels, vocal efforts (voice levels) and distances between communicators have been quite thoroughly investigated (first by Beranek, Trans. Am. Soc. Mech. Eng. 69, 97–100, 1947, and later by Webster, ASHA Reports 4, 49–73, 1969). These relationships, called Speech Interference Levels or SIL, involve measuring the levels of noise in three octave bands in the speech range—roughly 350 to 3,000 Hz.—averaging them, and reading from a table (Beranek) or chart (Webster) the vocal-effort and interspace-distance requirements for reliable voice communications. The SIL chart can be used in reverse to specify room noise criteria that will allow communications between communicators some fixed distance apart; for example, to communicate at three feet, the ambient noise should not exceed 70 dB(A). To keep from raising one's voice except to communicate over distances of 100 feet, noise levels should not exceed 50 dB(A)." And that is the end of Dr. Webster's.

These paragraphs make it clear why people complain so much about aircraft flyovers. At levels well below those that would be hazardous to hearing, even if the daily exposure were several hours, severe interference with communication (either conversation or TV reception) is seen to occur, and annoyance is expressed.

The problem of annoyance, of course, is a real bag of worms, as this series of hearings has made abundantly clear. That was written a month and a half ago, but I knew it would still be true!

Dr. **Meyer**. I would think it would be more true now than it was when you wrote that!

Dr. **Ward**. Although there is a correlation between noise level and annoyance, the correlation is only general. The 30-dB drip of a faucet or crying of a neighbor's baby may be as annoying as the 85-dB noise of a waterfall by which one is camped. We feel, therefore, that Federal regulations based only on the annoyance value of noises are impractical; they should be grounded only on considerations of hazard to hearing and interference with speech communication.

This conviction would have to be modified, naturally, if nonauditory effects of noise are ever finally shown to be deleterious at exposure levels judged to be safe for hearing. In the presence of broad-band noise above 70 dB(A), vasoconstriction in the extremities does occur, and this is maintained as long as the noise is on (G. Jansen, ASHA Reports 4, 89–98, 1969). At intensities above 95 dB(A), this reaction is quite marked, and so exposure could conceivably result in some harmful physiological consequence at exposure times less than those that will damage the hearing directly—but this has not been proved. In fact, it has not been shown conclusively that extra-auditory damage occurs until exposures exceed present damage-risk criteria considerably. Despite decades of experimentation both here and abroad, no convincing evidence has been found that a noise exposure that is safe in regard to hearing is physiologically hazardous in some other respect. Remarkably little effect on mental or physical efficiency has been seen even in noise levels well above 100 dB(A).

Although we feel that strict Federal controls should apply only to noises that are hazardous to hearing and/or interfere with communication, this should not be construed as indicating a lack of concern on our part with what is popularly called "noise pollution." We feel nearly as strongly as do the most outspoken anti-noise crusaders that the assault on all our senses due in part to greater mechanization and in part to our ever-burgeoning population should be resisted strenuously. The use of internal combustion engines in or over our wilderness areas, the development of ever-noisier aircraft, the increasing "traffic's boom," even that canned unmusic that permeates some hotel lobbies, all represent increasing encroachment by someone on somebody else's auditory space. Such infringements on personal peace and quiet should continue to be fought by means of local regulations, just as the Sybarites of ancient Greece banned from the city limits not only metalwork but also the keeping of roosters. But we feel it is important that we oppose unnecessary noise made by anyone on the basis of the fact that it is a damned imposition, not on the strength of vague fears engendered by old wives' tables, anecdotal observations, unpublished research, unsubstantiated rumors such as about low-frequency death rays, or ambiguous results of experiments (especially those on animals) on non-auditory effects of noise.

In short, it is our opinion, based on the present literature, that if people are protected, as they must be, from noise exposures that are hazardous to hearing, they will probably be automatically protected from any untoward non-auditory effects as well. If they are protected from noises that cause more than a minute or so of interference with speech perception, we are certain that such protection from non-auditory side effects will occur.

Dr. **Meyer.** Could you wait about 2 minutes while I take a phone call, Dix, before going on with the rest of your—

Dr. **Ward.** All right.

(Short recess.)

Dr. **Meyer.** Okay. Let's continue. Sorry about the interruption, but I had one of those urgent phone calls that had to be taken care of.

Dr. **Ward.** What did Dick have to say?—Nixon. (Laughter)

Dr. **Meyer.** All right. Continue.

Dr. **Ward.** Well, now, I would like to talk for a few minutes anyhow about some of the evidence that has—some of the things that have been said this afternoon because I would like to defend the proposition that even with exposures that produce hearing loss, the extra-auditory effects are not yet proved hazardous.

I have been looking for non-auditory effects of noise for a long time. My first job back in 1948 with the Rosemont Research Center at the University of Minnesota was trying to study the effects of ultra-sonics on various aspects of the physiological and psychological aspects in men. We didn't find any then, and by and large we didn't find any to speak of in the study of flight deck personnel in 1954 to 1957, and I have tried to keep up with the literature since on the question.

All I can say is that if the burden of proof is still to be placed upon the affirmative, then there is no good evidence that deleterious results are ensuing from noise exposures that even may produce some hearing loss.

I have heard this phrase "considerable evidence exists" so often today that it is just making me ill because considerable evidence doesn't exist, and when people say that you can be pretty sure that they are on shaky ground. And I was hoping that individual studies would be cited by name so that I could tell you what was wrong with these studies.

Well, I have been able to pick out a few because of their unique characteristics, and let me just mention a few of these.

Let's turn first to the psychiatric effects of noise. This was a study by A. B. Wickrama, et al., published in Lancet in 1969.

Now, this is the study of the people who lived in Hounslow Borough near the airport in London. Now, they noted of 488 persons admitted to a psychiatric hospital and who also lived in this borough, whether they lived in or out of a maximum noise area of over 100 PNdB or above 55 Noise and Number Index—that is what the British like to use—and they calculate estimates of incidence from this. However, they admit that their figures for total population in these areas are only estimates, so their assumption that there were more people living in the nonmaximum noise area than in the maximum noise area is quite speculative. In actual fact, now, there were equal numbers of patients—either total or male or female—admitted from the maximum noise area and from the other area. However, there were twice as many widows admitted from the maximum noise area, 36 versus 19, and this appears to be the only thing one can place much confidence in statistically speaking in this whole study. Now, taken together with the fact that the maximum noise area is also a higher economic status area, one might conclude from this that there are more widows living in the maximum noise area; that successful men die younger; that well-to-do widows are more easily sent off their rockers; or, of course, conceivably that the noise does drive them batty.

Now, there is still a lot of work to be done before one can place much confidence in the psychiatric effects of noise.

Actually there is another one that wasn't mentioned that is quoted by Karagodina, et al., in Hygiene and Sanitation, which is a translation of a Russian journal, and they analysed 145,000 diagnostic cards and claim to have shown a higher by 2 to 4 times incidence of otological, cardiovascular, nervours, and gastrointestinal diseases in persons who lived 1 to 6 kilometers from airports compared to those 40 kilometers or more away. But they don't even say anything about socioeconomic status or the work or how many peasants are involved in one group and workers in the other.

So the whole field is full of this—well, it isn't quite hearsay, but it is certainly not very solid evidence.

Now, the only thing that we do know for sure is that vasoconstriction does occur. Jansen and his co-workers in Europe have studied this at length and have shown, as Dr. Welch indicated, that it does not adapt out. The question of whether or not it produces deleterious results is still open. However, again, Jansen has made one study which showed that this may be true. He studied 1,005 metalworkers and he divided the men into "weakly exposed" and "strongly exposed." And he found that there were more complaints of circulatory problems in the heavily exposed, such as paresthesis of the extremities.

So here is the one solid piece of evidence that should be followed up by studies in this country, but it has been 10 years and nobody has ever done it. So either we are awfully lazy or somebody has already done it and got negative results and didn't want to confuse the issue with negative results, and failed to report it.

Well, mention was made by Carr of "tension-related diseases," and except for this thing that I quoted you on Karagodina, the only thing I could find in my notes was a study by Tarantola, et al. in Laboro umano in Naples, and they claim that the authors carried out clinical and radiological examinations of 73 workers employed in fettling malleable cast iron with fixed grinders, and the examination revealed deterioration of the digestive tracts after 1 or 2 years exposure frequent symptoms in 60 percent of the cases.

Well, now, this is an abstract, and, of course, if you don't read Italian, you can't go to see what they really did, so I can't really criticize it. It may be very accurate. It may be that this is good evidence for digestive tract upsets, but it is very flimsy evidence.

I think that my position is pretty secure. I don't feel much more worried about my position on extra-auditory effects of noise than I do about my position on extrasensory perception. I have never believe in that either. Now, it is the obvious that at high enough intensities we are going to get extra-auditory effects of noise. But anything reasonable, I still think that we have not yet shown that the panic button should be pushed, and that we should give sober thought to continuing research, but that we shouldn't scream that the noise is driving us all batty, and I am not even sure it is doubling every 10 years.

I might make one final comment. Let's bring this right out into the open and call a spade a spade. We are never really going to get good studies of annoyance values of noise, how people respond, in this country, because this would be invading privacy. The only way that you are going to really get good data is by going into a home and "bugging" it so that the people don't know they are being observed and, of course, this is un-American so it will never happen. So you can't castigate, I think, one particular worker more than another just because he does it a little bit differently. We are all stuck until somebody has the—well, I don't know what it would be—the courage, the guts, to perform an experiment like this, and to see if he could get away with it.

But I am convinced that if we are really going to determine what the reactions of people are to noise in terms of annoyance, this would be the best way to do it, and I don't think that we are ever going to.

Well, I do have one more comment that I would like to address in regard to the scientific method. I object to the absolutist approach in scientific method that you have got to have a concrete theory before you can go ahead and do the experiment. Possession of a theory does not guarantee good research, whether good is defined as significant, conclusive, or reproducible, because goodness knows a lot of experiments have been done by people who have theories which are held so strongly that they interpret their results in ways that a reasonable man would not. And in this case, you see, the possession of a theory was an actual drawback. So I think we shouldn't be too adamant about having to have a concrete theory before we start gathering data.

Dr. MEYER. Very good, Dix. Thank you for giving us the other side of this coin that is being tossed in the air quite a bit about the significance of certain effects.

I would like to ask Dr. Eldredge if he has any comments.

Dr. **Eldredge**. No. I think many of the points Dr. Ward has made, especially with respect to hearing and the effects on hearing, are quite good. I think we know these very well. I think the way he stated the risks as a series of steps is a very useful way to do it.

I think I would agree with him that the extra-auditory effects have not been demonstrated in the sense that he was describing them. I might ask him though if he thought people did pay a little extra without harming them necessarily for having to work in a noisy office as opposed to a quieter office. Where is the evidence, again, if you use them?

Dr. **Ward**. I mean are you leading up to the old Harvard experiments, for instance, where as soon as you take noise into a laboratory the deleterious effects seem to disappear. Although it seems reasonable that performance would suffer, only in these vigilant studies of Broadbent can you demonstrate a significant effect. Somehow people—if you would like to say that they expend more energy, fine, but has this ever been studied actually urbanomically? I don't know.

Dr. **Eldredge**. Well, I think one thing you could say is that it is very obvious if you are going to have to raise your voice to communicate and this is part of your job this is something extra.

Dr. **Ward**. My main criticism is not the concomitant extra-auditory effects of noise, but the enduring extra-auditory effects of noise. No, there is no question but what there are concomitant effects of noise, but whether they have any permanent effect on the person is what is moot.

Dr. **Whitcomb**. Also you were saying below damage levels, and once you are raising your voice considerably you are probable below damage strength.

Dr. **Ward**. Not necessarily.

Dr. **Whitcomb**. I have no comments unless—I think Henning may want to comment on hiding inside somebody's home. He has been wanting to do this for years. (Laughter)

Dr. **von Gierke**. First, I want to endorse your criticism of the various studies on long-term physiological effects of noise. As I tried to indicate several times today during the hearing, I think there is really no clear evidence that any of these permanent irreversible effects occur. Nothing has been documented, as we discussed by discussing the individual studies, and as we tried to point out several times most the animal experiments which have been done are poor and cannot be transferred to human situations.

With respect to the observation of human behavior in response to noise, and annoyance response in the real world environment, I am not quite as pessimistic as you are that it could not be done in this country. I think there are group situations in college dormitories, or in military quarters where you could very well have trained psychologists among the group to observe the reaction of these individuals and groups to noise interruption, and observe, on objective basis in the field, what interruption of speech communication and of television viewing, and so on, would occur. So it might be difficult, but I think it is not impossible to design such experiments.

Dr. WARD. Well, at one time, we were going to study—when we started on this Anehin project in 1954, we wanted to study the effects of noise on sleep of these sailors and we were going to wire up the bunks to record movement, but we were vetoed on this so we never did it.

Dr. FIDELL. In general, complete endorsement of what Dr. Ward said. One clarification perhaps: When I was speaking earlier of the necessity for a theory, that was a code which I have devised for myself meaning you have to know what you are doing. At the time I didn't want to appear that blunt. I also suggest that some people didn't know what they were doing. But I did not imply that you must necessarily have a formal theory before you conducted any research.

And in keeping with Dr. Ward's belief that brevity consistent with clarity is the criterion by which we should judge our comments, I shall cease here.

Dr. BOTSFORD. One question. You said you thought noise standards for equipment should be set only on the basis of risk of hearing damage or speech interference, and not on the basis of annoyance.

Now, it seems to me that there are some things that are clearly annoying like motorbikes or snowmobiles, and the noise standards ought to be set on them as low as it is feasible to set them without any regard for whether it interferes with speech or hearing. If you set them on that basis, you would set them much higher. Now, would you elaborate on your position there?

Dr. WARD. That is just my personal preference, you see, and I was able to convince the members of my Committee that it was a reasonable one; while a Federal control, it seems to me, should be based on health and welfare—I mean health not on well being. And it should be up to the individual communities to decide—for the majority to decide to what extent they are going to impose their will on the minority.

Dr. VON GIERKE. You don't endorse the definition of "health" of the World Health Organization.

Dr. WARD. I certainly do not, because I don't know what it means in the first place.

Dr. MEYER. Well, unfortunately the dilemma that is presented is that in a number of instances Congress has accepted that definition of "health" and has written it into the statutes. That is the dilemma, Dix, that we are in.

Dr. WARD. Which shows that international organizations are even more dangerous than national ones.

Dr. MEYER. Well, I am not going to get into a discussion on that on this platform—(Laughter)—but in any event, even if you don't accept the World Health Organization definition, one of the problems we get into is that there is something called welfare and it is also utilized, as in the air pollution and the water pollution laws. It is a pretty extensive definition that extends all of the way to the effect on things that people own as well as on themselves. And while I would like to put myself in a position of saying that I would basically personally agree that we need to know a great deal more, the fact still remains that the Executive Branch takes its instructions from the Legislative Branch. The

Congress often says consider "health" and proceeds to define the term beyond just physical deterioration or the absence of disease, and also includes terms like "welfare". And in the legislative history—which is a thing, as you know—and I want to point this out—the legislative history gives you an indication beyond what the specific words are, and then the committee report, which is part of the legislative history and the statements by the members of the congressional committees in eliciting the testimony at the time of consideration of the Act all have to be taken into account. To date, the legislative history about testimony relating to proposed noise legislation clearly indicates that there is more to be taken into account in setting standards than impact on hearing or on speech communication. While from a scientific and technical viewpoint one would have to say that there is much merit in your position, it does not necessarily make it any easier for this Agency in implementing the act of Congress. It simply is one of the factors which will now have to be taken into consideration.

Dr. WARD. I am in sympathy with your problems.

Dr. MEYER. It is one of the things that was pointed out in a paper that I gave before a learned society the other day. We must take into account the public's views demands as well as those of people in professions and in professional societies. And that is why we are having this hearing, as a matter of fact.

Do you have another comment, Henning?

Dr. VON GIERKE. Yes. I think fortunately for both of you, there are many of us who feel that there is a strong correlation between annoyance and speech interruption, and I guess depending on how you define your interference with speech complications that means for what time period you want no interference. You might set the noise standard for speech interference very close to what other people would set them for with respect to annoyance.

Dr. MEYER. Well, I think that is an important point. Because in a lot of our thinking, certainly the correlation between certain environmental noise values and ability to converse has been used as a rather gross indicator of annoyance. We have all, I think, agreed that, if it is so noisy you can't hear the person standing beside you, that that certainly is a measure of annoyance.

Dr. WARD. But by the same token though we have no right to say to someone: this bady crying that you are objecting to is not loud enough to interfere with your conversation, therefore you have no right to be annoyed. So there you are.

Dr. MEYER. That is the dilemma we are caught up in and yet we have still got to come up with a meaningful system, so we are going to count on your help in the future to help us come up with the solution to the problem—you and all of the rest of your colleagues. (Laughter)

Dr. WARD. Thank you.

Dr. MEYER. Thank you, Dix. I hope you will stay around for the remaining two papers, both of which have an important bearing on the item which you have just raised.

I would like to ask Dr. Glenn Jones, if he is still here, if he would come forward and give his statement with regard to "Psychological Effects and the Problem of Abatement."

## STATEMENT OF GLENN JONES, SENIOR SCIENTIST, BOLT, BERANEK AND NEWMAN, CAMBRIDGE, MASS.

Dr. JONES. I did want to relate psychological effects definitely to the problem of abatement because I think that there is some choice of priorities, and that there is some choice of what may be important and what may not be important in this context.

I would like to enter a disclaimer immediately, however, that these choices are not necessarily choices between basic research and applied research. In fact, I think I would agree with the tone of both the panel and the witnesses today that focus on basic research in this area is very much needed.

I do think that the Environmental Protection Agency, as I have said in the written statement, is on a very real adventure, and I am inclined to believe—have a bias in this regard—that it can indeed be a very successful adventure. As a social psychologist, who is somewhat weighted on the sociological side, I would think of the Environmental Protection Agency coming into existence because of some basic changes in values in our society, and would be hopeful that the Environmental Protection Agency and the Office of Noise Abatement and Control would look upon its mission more of adjusting our social relations to these basic changes in value than being some kind of a contest between those who make noise for reasons of economy, on the one hand, and those who are listeners are assaulted, on the other.

I think that the kind of advocate notion will get us into a lot of dilemmas that a common values notion, where it can be pursued, may get us out of.

Let me develop the abatement problem, as I see it, in terms of—in sociological terms, first, and then talk about some of these psychological effects that have been discussed already today within this context.

Let me take as a model for this abatement system, as I see it, the air transport industry considered broadly and as a whole social system. In doing this, I will promise not to duplicate what I understood to be yesterday's discussion. But the air transport system, if we look at it as a whole, is a remarkable socio-technical system which achieves a very remarkable output in terms of useful output under exceedingly difficult circumstances and under complexities that are bewildering, and I am sure that no one of us really comprehends.

In general, that system is a system in balance, in the sense that most of the parties to the actually contribute something to the system and at the same time derive certain benefits from it.

For example, the relations of passengers to airlines and airlines to manufacturers and suppliers are basically determined in a market. Now, it is a somewhat regulated market in this industry, to be sure. It is not quite an open market, but nevertheless it is a market with that kind of free exchange.

Airline and airport relations are contractual in nature—well understood—and there is an exchange here. Airports themselves, many of which take the form of public corporations, achieve a complex integration of the interests of local civic and governmental groups, the Federal jurisdiction as it impinges upon them, airlines, consessionaires, and the traveling public. And the relations between industry and government, in the regulatory sense, are very complex. But nevertheless they are orderly and understood by all parties and are primarily addressed to the safety and convenience of passengers and the public, and to the health and orderly growth of the air transport industry, which then is recognized as being a social good in the sense of its contribution to our total economy. This presents a very balanced picture.

However, there is one constituency that pays a heavy cost for the existence of the air transport system who realize no more benefits from it than any other citizen does. Let me make that distinction. It is not that people who are impacted by noise around airports are not benefitting from the air transport industry; it is that they are not any more benefitted by it than the rest of us. And therefore their costs that they pay, in a sense, are disproportionate.

We cannot put a dollar value on the system's cost to them, but it can be spread out, spelled out, in terms of interrupted conversations, interrupted TV and radio listening, interrupted classroom teaching, interrupted church services, interrupted outdoor play—where the children will get their hands over their ears, which actually has happened—interrupted rest, interrupted sleep, and annoyance and frustration.

There may be—and this is controversial today—physiological and psychological costs of a less immediate nature of which we are only dimly aware, of which some of us may suspect and some of the others of us may not.

Now, the whole point here is that the system—great as it is and fine as it is and efficient as it is—has from a sociological point of view, point of view of a social system, this glaring defect that it has an element which does not actually participate in the exchange. There is a cost without a benefit. And it also is to be noted that even if abatement is sought—that is a lessening in the cost—not any benefit, but a lessening of the cost—the channels through which these people generally can influence the system are long and tenuous.

Sometimes, of course, these people have access to airports through complaint mechanisms, but they have no orderly way to confront airlines, and except as we heard the one example today as neighbors of confronting pilots who live in the area, and airplane and engine manufacturers are just unspeakably remote from them.

Now, there has been, in a kind of marginal way, some influence exercised through the channels available—there are airports which do indeed modify their flight paths in order to minimize the impact of noise upon people. And, of course, the Federal Aviation Administration has now in effect put a ceiling on noise that is made by individual aircraft.

However, it is perfectly obvious that even with larger aircraft, if indeed air traffic does increase, the ceiling is not going to—it will decrease the rate of increase—it will mitigate that but it actually will not turn down the noise impact. It will not lessen the noise impact over a period of time.

However, there is another aspect to this, and here—in all of what I am saying now, I am trying to apply a sociological model to a situation on just an observer's basis; I am not being scientific at all—and in the next thing that I say, I am going to be highly speculative in almost a sense of challenging anyone to produce evidence to the contrary. But it does seem to me that although people who are noise-impacted, in a sense have been quite powerless politically, quite powerless in their ability to protect themselves from this noise, they have had unconscious, unplanned effect upon the whole aircraft transport system, which is becoming more and more apparent. And that is that it seems increasingly difficult to establish new airports to take care of the expanding traffic that exists. And, as I am sure you heard yesterday there are—and this is very common with airports in the United States at the present time—there are lots and lots of controversies between airport neighbors and the airports themselves over expanded facilities and the opportunity to carry more traffic within existing airports.

This, then, becomes what I have in the paper described very frankly as a very nasty kind of picture because on the one hand you have a group of individuals who are paying a charge for which they get no benefit and have been relatively powerless to do anything about it—what has been done has been more or less fringy in nature—and on the other hand, a restriction of growth of this system which has had the power, in other words, to preserve itself in its present state as an organization if it is successful must do, but is now in a position where it is losing its power to expand. So that I think it is a reasonably safe statement to make that noise now constitutes the chief barrier to expansion of the whole airport system.

Now, let me say that I developed this not in a spirit of entering into the airport controversy as much as to put it up as a kind of social system analysis which I think has generality for all of our noise impact. It is at least generated by transportation systems or some kind of industrial—by our technology—and may be equally applicable to other areas of pollution, such as water and air. It can be taken, then, as a kind of a general model, I think, for pollution in social system terms.

Let me point out to you a rather peculiar thing: that if this line of reasoning is essentially correct, noise which was considered from the standpoint of physics and physiology and psychology, and the rest today, can equally be claimed to be a sociological phenomena. It grows out of our socio-technical organizations and can be handled from this standpoint, and I think that it is profitable in the future that it may be.

I am sorry that he is gone—Dr. Eldredge just—

Dr. MEYER. He had to catch an airplane to get back to St. Louis.

Dr. JONES. Yes. But at the conclusion of the last statement—Dr. Ward statement did raise the question about: Was there any research indeed which demonstrated the effects of noise on efficiency other than the immediate effects? In other words, in the long-term effects.

There is a paper, whose senior author is Dr. Glass, who has already been mentioned, and the only one that I know which demonstrates in a sense the unconscious and long-term effects of noise from a psychological standpoint. This is a paper by Drs. Glass, Singer and Friedman—and it is cited as a reference here—

Dr. **MEYER.** Yes.

Dr. **JONES.**—and I would like to describe it a little more. I didn't realize how relevant it would be or I would have briefed myself down to the fine detail which I have actually not.

I would like to describe it a little more than has been done. This was an experiment in which groups were divided and exposed to different noise in terms both of sound level and the temporal distribution of the noise, their ability to anticipate it, and were given mental tasks to do—like adding up columns of figures, and the rest. And there is a clear demonstration in this section of the —this phase of the experiment that there is such a thing as adaptation. The adaptation was to the task. Actually those groups which were more highly impacted did improve so that the mean output of work of all groups—those of the control groups and the low-impacted groups as well as the high groups—did tend to converge, which the authors—and I think I would accept as evidence of adaptation to the noise.

In fact, the statistical differences between the several groups is not significant. However, what these people did that is very important to us, I think, was that after the noise ceased, people were given another set of tests and subjected, then, to a stress experiment in order to measure their tolerance for stress. And in these cases, the results were highly significant—statistically significant, and did indeed indicate that in carrying out tasks after the noise was finished, their efficiency was diminished if their noise exposure was high or if the noise was intermittent and therefore could not be anticipated.

Furthermore, on a respectable level of statistical significance, it was found that these people were less tolerant to frustration, as they were exposed to more noise and as they were exposed to noise which was unanticipated.

This, I think, then, indicates that there is adaptation, and I would be the last in the world to discount the amount of adaptability of the human being. But, on the other hand, I think that it also indicates that there are costs to this adaptation, and these costs were measured in terms of deteriorated performance and of less tolerance to frustration.

This is a short-term experiment. It is the only one in the psychological context that I know which has to do with this area that we have been—that, in a sense, are not direct results of the noise itself, are not direct reactions to noise, and I think it is very important, however, that this line be pursued.

It seems to me that a second trend that will influence abatement technology in studying the effects of noise is that currently we are much more sophisticated about the stimulus—I am speaking now on psychological level studies; not physiological—but are much more sophisticated about stimulus than indeed we are about the reaction.

Let me simply cite as evidence the degree of sophistication that we have in the measurements of the stimulus—most of them, of course, in physical terms—but we have a basic measure of decibels which is well established, well understood, and out of that, then, have a number of permutations taking into account other conditions such as spectography modified by such things as dB(A)—and this is not an area with which I claim any expertness at all on—but also certain temporal modifications, such as take place in PNdB, or in Traffic Noise Index, or in the Noise Pollution Index, and other similar measures. We have the CNR, which takes into account and integrates a number of conditions, and then predicts to behavior.

On the other hand, the behavioral measurements or the subjective measurements that we have are, to my knowledge, at least completely understandarzied. I should make one exception to that. I think rather consistently in aircraft studies, the Gutman scale that Borsky originally developed has been fairly consistently applied in terms of activity interference. But with this exception, we do not have good measures, and I think that this measure itself has not really been tested. I think it has been used and wisely; as a matter of tradition, once established, it is the thing to use. But I think it has not been rigorously tested in these terms.

It seems to me that we need something like a decibel scale here. We won't get one as good. After all, the art of psychological measurement is not nearly up to the art of physical measurement. But, on the other hand, it is not a lost art either, and it does seem to me that we ought to decide somewhere to put an effort into trying to get a safer measurement of behavioral reaction output that in turn can be elaborated according to the purposes that we have in mind. And although I hate to do so, I run headlong into Dr. Ward in my suggestion by suggesting that this may well be the area of annoyance.

I think it would drag out the discussion too long to say why, and certainy drag out the discussion too long to say what the errors of the past have been. But it does seem to me that annoyance has an outstanding virtue in that it can be used, if we will develop it that was, as some kind of measure—a separate coinage, if you please—of psychological cost. I think it has this element, this potentiality in it, and while I hesitate very much to say it can ever be translated into dollar terms, nevertheless as a common element within the psychological area. I think it can do that.

The work that has already been done with it, including the testimony of Dr. McKennel in England, is that it is a very robust kind of measure; it has a single robust measurable factor; it isn't a complex kind of thing in terms of the dimension which one measures, and yet the dimension itself is sensitive to a number of things. We have already had the studies showing its sensitivity to attitudes towards the source, and a number of other kinds of variables with which it fluctuates, so it is sensitive in those terms.

It is more remote, further down the line, and I think Dr. Borsky gave us a good model of the line this morning, proceeding from the stimulus on through the ultimate reaction, through perception, and the other stages. It is down the line somewhat from perceived noise, which Dr. Kryter has developed, in that it does include attitudinal and susceptibility factors, factors of this sort, but is not as far down the line as complaint behavior which get contaminated not only by the individual reaction, but by the complaint system itself, and a number of other factors. And, for example, the probability that the subject has that he will get some kind of abatement, I think, he doesn't get contaminated in this sense.

So I think that there is good reason to believe or that there is reason to concentrate, then, on some kind of standardized behavioral measure which will give us a tool which we will use, and which we will understand. And the development of these tools are possible; indeed they have been done in areas like organization research. I think we have rather good tools for judging the satisfaction of a job, for instance, that have been developed deliberately and on the basis of planned projects.

I have cited data to indicate that perceived noisiness is not at all annoyance. We have recently completed a study of motor vehicle traffic in which 80 percent of the people interviewed said that motor vehicle traffic contributed to the noisiness of their neighborhood. We asked them about the noisiness of their neighborhood. At the same time, only 44 percent of the people were annoyed by the noisiness. This, I think, is similar to the measures that Dr. Borsky was citing this morning, and actually is somewhat similar to the levels—citing this morning the difference between the perception on the one hand and the actual attitudinal type of reaction which annoyance is, on the other.

I would like very briefly, at this point, to add one other kind of finding to the record that is not in the formal paper that you have.

Recently we discovered a special case of attitudes towards the source of noise that I think may be very helpful to the abatement procedures that you develop.

And this involves the control that the noisemaker himself has over the noise. Dr. Borsky mentioned it. I know of no other empirical data regarding it. However, we could indeed account for some of the variance in this very complex situation by the fact of whether or not people believe that the driver could easily control, control with difficulty, or could not at all control the noise that was made.

We asked people to give their phenomenological impression of the loudness of the sound without any reference to a physical measure, as well as their annoyance, and we did find that this factor of control accounted for a good deal of the difference that we saw between loudness, on the one hand, the lack of coordination between loudness, on the one hand, and annoyance, on the other. I don't mean that lack of coordination was complete. Perceptual loudness accounted for more of the variance by far than any other factor that we measured, and we aren't about to throw Stevens out of the window here. But nevertheless, we could account for some of the differential fluctuations by plugging in this factor of how much control.

Also we got similar effects when we asked whether or not the driver of these vehicles was driving legally, and got here again a differentiation in levels of annoyance based simply on the question of whether or not the driver was driving legally. So that if these findings are typical—and it is only one study—it does indicate that people may make allowances for legitimate noise, and may, then, not only—not make allowances—this is why I like the annoyance variable so much as a dependent variable—may indeed be more annoyed by noises which they do not consider legitimate or which in some sense they do consider to be under the control or not under the control of the individual who is making them. Therefore, diesel truck drivers get off much more easily than people who make exhaust noise because exhaust noise is annoying. Actually it is accompanied by an identification of deceleration of noise, and the rest.

Let me say in support of this advocacy that I am making of an annoyance measure that we must distinguish between measurements that are taken on individuals and measurements that are taken on groups—even groups of a fairly small size. Over and over again we can cite you all kinds of evidence to indicate that we immensely increase our reliability. And in this study that we just completed, we asked a question that we thought was ridiculous, and that is we asked people what part of the vehicle made the noise. And yet time and time again, in our analysis, actually the way that hangs together does indeed make a tremendous amount of sense with the other kinds of variables involved. So that we did feel—and this is not alone in the noise field; this has been found in air pollution, too—that often when you get group judgments, the reliabilities increase tremendously, and much of the individual perturbations do indeed some random across individuals and can be factored out.

Well, we have talked about the control, then—the matter of control of the person who is making the noise. Going back to the Glass, Singer and Friedman study, they injected another element into their study in which they gave people the option of controlling the noise that they heard but gave it to them in such a way that they didn't have a great incentive to exercise it. No one did indeed exercise it during the experiment. But the difference between those who were assaulted by the noise, in the sense they could not control it, and those who could control the noise, could have turned off the noise had they desired to do so, was again very great. So that part of the annoyance, we think—part of the effects of noise are these effects as to whether or not indeed people can control it.

Finally I would like to say a couple of things about the area of public opinion with which social psychologists are concerned and a concern that I think you people are sharing.

In the motor vehicle noise study referred to above, just on a very raw basis, we found that we could account for 5 percent of the variance simply by asking people: Is this annoyance or is this situation—which was kind of the unit that we talked to them about—is this situation one that you feel is shared by the public, by just a few friends, or by yourself alone? And we found—and this is very unusual in scale attitudinal research—we found a difference 1.2 of a scale, which for a large group is a very large difference between those who felt that they alone were annoyed and that they shared public annoyance. We think this is rather important because if there is a coalescing, in a sense, of the noise, and people do indeed share the notion that they are annoyed, then their annoyance will not only be greater but the public opinion in that area will probably be much stronger than if we have a whole bunch of individuals who sort of are ignorant of each other's annoyance. Incidentally, most people did feel that, in the motor vehicle area, their annoyance was shared.

We are not, of course, sure of the direction of causation here. We are not sure that maybe people who are very annoyed don't naturally think, then, that the people share their annoyance. I don't mean to make this implication. The implication I mean to make so strongly here is that group factors and the consciousness of group factors do indeed enter strongly into this area.

Another important aspect to public opinion—and there is no data on this, I think, however—is the degree to which the public values silence. And it is important to ascertain, I think, whether people, in a sense, particularly as one deals with industry—whether people do indeed have this as a personal value or whether it is something that they feel is imposed on them from without. And I think it is very important to get some gauge of the extent to which the environmental movement and the whole ecological movement is now truly seated in our public values.

I think through survey methods that are well known you would do well to apprise yourselves of these facts, because I think, on the basis of what truly is out there, there will be determined a boundary of what indeed one can do in the abatement of noise.

Dr. **Meyer.** Dr. Jones, first, I would like to state that your prepared statement will appear following this verbal transcript because it is a useful documentation of some information with references, and so on.

(The document referred to above follows in its entirety.)

## NOISE: PSYCHOLOGICAL EFFECTS AND THE PROBLEM OF ABATEMENT

### Testimony by Glenn Jones

Mr. Chairman: I should like to talk about some of the psychological effects of noise; but, with your permission, I should like to talk about them in the context of abatement, in the context of the great adventure that the Environmental Protection Agency is launching upon. My general bias is that, if we approach this task as a fundamental accommodation of our society to a new set of values rather than the expeditious accommodation of a conflict of interest, that the task is possible and that its outcome will be profitable.

If we first develop the abatement problem in sociological terms, perhaps we can subsequently develop some of the psychological consequences of noise more meaningfully.

One of the socio-technical systems that is generating the most noise pollution is the air-transport system. Because it is visible and because more is known about the noise it generates than about the noise most other systems generate, we may use it as a prototype, even though aircraft noise *per se* may presently be of less direct concern to the EPA's Office of Noise Abatement and Control than noise from other sources.

In the large view, the air transport system is surely one of the marvels of organizational achievement. Essentially, it operates as a balanced system in which a complex exchange of resources takes place to which all parties contribute and from which all parties benefit. The relations of passengers to airlines and airlines to manufacturers and suppliers are basically determined in a market, a somewhat regulated market to be sure, but a market nonetheless. Airline-airport relations are contractual in nature. Airports themselves, many of which take the form of public corporations, achieve a complex integration of the interests of local civic and governmental groups, the federal jurisdiction, airlines, consessionaires and the traveling public. Industry-government relations, which, while very complex, are, nevertheless, orderly and understood by all parties and are primarily addressed to the safety and convenience of passengers and the public and to the health and orderly growth of air transport as an appropriate constituent of the total economy.

However, there is one constituency that pays a heavy cost for the existence of the air transport system who realize no more benefit from it than any other citizen. They are, of course, the noise-impacted neighbors. While we cannot put a dollar value on the system's cost to them, it can be spread out in terms of interrupted conversations, interrupted tv and radio listening, interrupted classroom teaching, interrupted church services, interrupted outdoor play while the children get their hands over their ears, interrupted rest, interrupted sleep, annoyance and frustration. In addition, there may, of course, be physiological and psychological costs of a less immediate nature of which we are only dimly aware.

While in a strict sense those who pay these consts are a constituent of the air-transport system, they are outside of the air-transport *exchange* system. They derive no benefits by reason of their costs. Furthermore, the channels through which they can influence the system are long and tenuous. They sometimes have access to airports through a complaint mechanism; but they have no orderly way to confront airlines or pilots, while airframe and engine manufacturers are even more remote.

Some influence has been exerted through these tenuous channels. At some airports, flight patterns have been modified to decrease noise impact; and the Federal Aviation Administration has, in effect, put a ceiling on the noise any single aircraft is permitted to make. The noise growth rate has thus been slowed, although as air traffic continues to grow, given the present regulations, noise will grow with it. Given the present system, there is no relief in sight for those who are supporting the system involuntarily by bearing the assault of its noise.

This is not to say that they are without influence on the system, even though they are getting little of the abatement they desire. For this system, like any other soical system, depends upon its environment for support. This is critically true of the support a system needs if it is to grow. And it is becoming apparent that the unrelieved prospect of jetport noise will impede the growth of the air transport system. Inspired by the fate of those who already live near airports, one community after another is driving off those who would establish a new airport nearby, not to mention the numerous cases where airports and neighborhoods are locked in combat over the expansion of existing facilities.

This is a nasty picture. Good people on the one hand assaulted by noise without hope of abatement, and a useful social system on the other that seems to have no place to grow. The air-transport system can be taken as a prototype for other noise-generating institutions, indeed for polluting soicio-technical systems in general. From a sociological perspective, the task of the EPA is to modify the system so that the interests of those impacted by noise (or other pollutants) are represented and that the costs they are now bearing without compensating benefit will be shifted to those who do derive benefit from the system's operations.

We turn now to certain psychological effects of noise that are directly related to this task and would logically affect the manner in which it is carried out.

What little we know about the psychological effects of noise concern immediate effects at the conscious level. Only one study that I know of deals with unconsious effects of noise and none that I know of deal with permanent psychological changes that have been induced by noise. The study (Glass, Singer, and Friedman, 1969) shows that, while subjects had great ability to adapt to noise, so that the effects of noise on mental tasks seemed minimal, that after the noise ceased, their efficiency was seriously impaired as was their tolerance for frustration. This study is out of the literature of the social psychology of stress rather than out of the noise literature, but opens up possibilities for discovering costs of noise that remain virtually untouched.

A second trend that will strongly influence abatement technology is that, in studying the effects of noise, we know much more about the stimulus than we know about the reaction. We have not only developed a standard decibel scale for sound pressure, but numerous ways to measure loudness and special ways to account for time-dependent and other phenomena as applied to aircraft noise, traffic noise, and noise pollution in general. There seems to be a high correlation in the ability of these measures to predict reaction, even though the measures themselves seem to be quite different. May I gently suggest that these correlations may not so much reflect the homogenity of the measures as the lack of discrimination in the output or response measurement to which they are commonly compared.

We need output measures of similar reliability and sophistication. Without describing the present jungle in which we operate, let me suggest a serious effort to improve our conceptualization and measurement of annoyance. It has been shown to have a strong single factor constituent, (McKinnel, 1970), yet, as an aversive attitude, it is conceptually rich. It is influenced by such factors as attitudes toward the source of noise (Borsky, 1961; Cederlof, Jonsson, and Sorensen, 1967; Jonsson and Sorensen, 1967); by the control the source has over the noise and his ligitimacy in exercising it (BBN, 1971); by the susceptibility of the auditor to noise (*Noise*, 1963) and many others. While complaints predict to annoyance, complainants constitute a distinct subclass among the annoyed (Borsky, 1961; McKennel, 1970; TRACOR, 1970). Annoyance is a stronger reaction than Dr. Kryter's concept of perceived noisiness (Kryter, 1970). In a recent study, 80 percent of those interviewed thought that motor vehicles contributed to the noisiness of their neighborhoods, only 44 percent were at all annoyed by this noisiness. Above all, I would commend annoyance to you as a measure of psychological cost and believe that useful, standard scales can be developed to measure it in this context.

Finally, I should like to say two things about public opinion. In the motor vehicle noise study referred to above, we found we could account for five percent of the intensity of annoyance by whether the auditor believed the public generally shared his annoyance or whether it was peculiar to him or to a few friends (BBN, 1971). Those who believed their annoyance was publicly shared were much more annoyed than those who believed they alone were annoyed. We are not sure of the direction of causation here, but this does indicate that annoyance has a group dimension that an abatement program can make use of.

Another important aspect of public opinion is the degree to which public values including the values of those who are subject to regulation include the abatement of noise. It is important to ascertain the value that people place on quiet and the degree to which people feel this value is shared. The degree to which this value is publicly held will largely determine the limits to which an abatement program can be pushed.

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Dr. **MEYER**. I would like to ask Dr. Whitcomb if he has any questions.

Dr. **WHITCOMB**. Since my memory is short perhaps I will start with a comment on your final statement. You point out if the public doesn't value quiet that legislation that is rather restrictive may turn out to be poorly enforced, and it sounded to be much like prohibition, I presume.

Dr. **JONES**. That is right.

Dr. **WHITCOMB**. This is a good point to keep in mind.

Dr. **JONES**. That is right.

Dr. **WHITCOMB**. You can go too far in being restrictive.

Dr. **JONES**. I might go off the record just a minute.

(Discussion off the record.)

Dr. **MEYER**. Let's get back on the record.

Dr. **WHITCOMB**. All right. I have a question with regard to your point on S/R correlations between the stimulus and the noise reaction.

Dr. **JONES**. Yes.

Dr. **WHITCOMB**. You pointed out that the high correlation may be more a function of the extreme homogeneity of the stimulus side measures and may actually be also the result of the homogeneity, I think you say, in these measures and not—well, it may also be enhanced by the lack of discrimination in the output of response measurement.

Do you mean by "lack of discrimination" unreliability in the response measurement?

Dr. **JONES**. Not so much as the response measurement itself may be a very gross kind of thing.

Dr. **WHITCOMB**. But it could be very reliable.

Dr. **JONES**. Oh, yes, indeed. If it weren't reliable then you couldn't have a high correlation.

Dr. **WHITCOMB**. Then you couldn't have a high correlation.

Dr. **JONES**. That's right. I mean it is not discriminating in the way that they are discriminating.

Dr. **WHITCOMB**. I misunderstood your use of "discrimination."

And then finally your comment about noisiness; 80 percent of those interviewed thought motor vehicles contributed to noisiness in the neighborhood, 44 percent, however, were seemingly annoyed.

This doesn't sound too much like Borsky's report on Heathrow II. It sounds like a considerably greater percentage. Could you clarify that for me?

Dr. **JONES**. You mean a greater percentage of people who were annoyed?

Dr. **WHITCOMB**. Either commented at all about being annoyed or that they perceived the noise or who said they were annoyed. I thought he was down around 27 percent.

Dr. **JONES**. On annoyance, I think this is rather easy because we used the 7-point scale measure, single scale. We then made our 44 percent on the basis of everybody who said they were annoyed at all, where he was taking his two highest categories in the 4-point scale.

Dr. **WHITCOMB.** Secondly, where was the measure taken? This might have some effect.

Dr. **JONES.** How do you mean?

Dr. **WHITCOMB.** Where did you measure annoyance—what sort of a neighborhood?

Dr. **JONES.** These were urban neighborhoods. I am not going to claim a representative sample, but we will claim a very diverse sample, a sample, for instance, we know is biased in terms of upper socio-economic level. But it was a very diverse sample taken in three cities of about 60 neighborhoods with 20 persons in a neighborhood.

Dr. **MEYER.** Dr. von Gierke.

Dr. **VON GIERKE.** Just a brief comment on your introductory statement about noise being a main barrier now to airport expansion and airport acquisition. I really cannot share your pessimistic view in this area. I think noise is probably an indirect cost of this "transportation system," and we just have to adapt our system to the reality and pay the real cost. And I am sure by the time this is being worked out in the court, legislatively and administratively, you will have no trouble buying land for a new airport and developing it if the public really wants it.

Dr. **JONES.** Well, all right, then, I think this simply strengthens the point that noise being outside the system, until it is brought into the system, is hampering the growth. What follows that is that if it is brought into the system, then that barrier to growth will be changed unless, you know—well, let me put it, instead of saying "unless"—with some inertia, the inertia being the time that it represents the public opinion to change.

Dr. **VON GIERKE.** It certainly is in the system now on the side of the aircraft engine manufacturing plants. I mean the powerplants which are being produced will be less noisy than the ones we have and this will alleviate the system and the noise problem as we go along, and it was from these attitudes that we did not include it in the system, as you say, which brought us to the point where we are now.

I remember meetings exactly like this more than 12 years ago where the notion that one could develop quieter jet engines—well, it would just mean that you could just put less passengers on the plane and therefore it was not acceptable.

Dr. **JONES.** That's right.

Dr. **VON GIERKE.** And I guess now it is being accepted—

Dr. **JONES.** That's right.

Dr. **VON GIERKE.**—that the system must and will regulate itself, if we go ahead on this assumption.

Dr. **JONES.** Yes. What I was trying to point out was that the costs, then, were not only in this case to a group of people outside the system but the costs were being paid by the system itself in terms of its ability to expand. I would agree.

Dr. **VON GIERKE.** I don't know if you were here yesterday—

Dr. **JONES.** No, I was not.

Dr. **VON GIERKE.** I want to reemphasize again—but I think this can not only be solved by the air transportation system alone; it is the overall transportation system—passenger transportation system as well as freight transportation system—

Dr. **Jones**. Yes.

Dr. **von Gierke**.—rail as well as—

Dr. **Jones**. Right.

Dr. **von Gierke**.—high speed transportation to the airport. All this has to be incorporated into one system and studied as one system otherwise we will never get a clear solution to the problem.

Dr. **Jones**. You are right.

Dr. **von Gierke**. The second question—I mean you talked about a single measure for behavioral response. I assume this is very far off.

Dr. **Jones**. I don't know. Let me say this. When I talk about a single measure I am talking about a fundamental measure in the sense of dB would be a fundamental measure around which, then, you could adapt other measures to it. But I am talking about getting at some kind of fundamental measurement of psychological cost.

Dr. **von Gierke**. Still there are many behaviors here—many different types of behaviors and I understood you that you are aiming at one scale, which would integrate all behavioral responses.

Dr. **Jones**. No, I am not. I am indicating at a single scale which could then be a reference point for other behaviors, to which other behaviors then can be related. I think this is a much sounder approach.

Dr. **von Gierke**. I misunderstood, sir.

Dr. **Jones**. Yes. Well, I wonder—and again it is outside my area—about single number systems for some of the measures that are being done in this area. It hasn't come up in the discussion today. I am not competent to discuss it, but that isn't what I had in mind.

Dr. **Meyer**. I believe our next and last witness may have some suggestion as to a method of grappling with that.

Anything else?

Dr. **Fidell**. No.

Dr. **Meyer**. Well, the only point that I would like to make is that I am glad that you brought into this hearing's testimony the fact that all of what we are about ultimately has got to result in some sort of control technology, relating the state of the art with legal methods for abating the problem. I am glad that you have focused attention on the need for that sort of integration.

Dr. **Jones**. Thank you.

Dr. **Meyer**. Thank you very much.

At this point, then, I should like to ask our concluding witness, Professor Michael S. Baram, Massachusetts Institute of Technology Civil Engineering Department and the Boston University Law School, whose paper will follow logically some of the preceding comments.

## STATEMENT OF MICHAEL S. BARAM, Ph.D., CIVIL ENGINEERING DEPARTMENT, MASSACHUSETTS INSTITUTE OF TECHNOLOGY, AND BOSTON UNIVERSITY LAW SCHOOL, BOSTON, MASS.

Dr. BARAM. Thank you for the opportunity to talk to you today. I realize the focus of these hearings is on the physiological and psychological effects, yet I want to take this opportunity to present some views to you on a suggested systematic approach to noise abatement and control. My comments will be relatively brief. Unfortunately I have not had time to prepare some visual aids which would have helped in the detailed presentation.

Dr. MEYER. Your total presentation, Professor Baram, will appear in the record following the verbatim.

Dr. BARAM. I see.

I should add also the paper represents merely a beginning of some integrated work with colleagues in civil engineering and systems engineering at M.I.T. Therefore, I will quickly scan the paper, and submit it to the record.

Dr. MEYER. Yes. As I said, the entire paper will appear.

Dr. BARAM. Our objectives in looking at the development of a systematic approach to noise abatement and control were several, and we feel that we have come out with a rough approach to a systematic and integrated approach to the complex problem of noise pollution.

This approach spelled out here in outline form as a guideline for processes of analysis and decision-making and aims at a balanced understanding of all aspects of the problem rather than any detailed understanding of specific parts of the problem.

The multiple objectives of the outline are to assist EPA toward the effective accomplishment of its noise abatement and control objectives; to ensure that objectives are not displaced or modified by economic, political, or other difficulties in the analytical and decision-making processes; to articulate a systematic approach to the problem in its totality, which will enable technical, social, economic and legal information to be effectively collected and ordered for coherent analysis and decision-making; and finally to provide citizens in all sectors of society with this articulation, with this basic understanding of the full process by which noise abatement and control can be thereby assuring EPA accountability—as Mr. Ruckelshaus has recently commented, the question of accountability is a very important one for environmental agencies—and accountability can only be assured through informed citizen access to the process—informed in the sense that they fully understand the decisionmaking process.

In short, it is time for the social system to act on noise abatement and control despite the fact that the data might not be perfectly adequate. Data in most social systems is never perfectly adequate. Its social systems have to act on perceived problems. We feel such a situation presently exists about the noise, and I am sure you all do also.

On the second page of the paper is a brief summary of the outline. It spells out what looks like a fairly obvious sequence of tasks—five sequential tasks which we think should constitute a decisionmaking framework, task 1 being the development of a coherent framework for analysis of the problem—and this is going to be a very difficult task, as you are aware—for the collection and ordering of data for the ambient information and opinion on the general relationship which we feel is the fundamental environmental relationship of the emitter emitting through transformation in the environment to the receptor, and the receptor effects.

For this coherent framework for analysis into which data will constantly flow, the derivation of assumptions as to receptor effects and causal links to the emitters must be made, we feel, explicit, must be articulated, as these constitute the premises for any further decisions or actions.

Tasks 3, 4, and 5 all sort of logically follows. Task 3 is to consider alternative technical, economic, and regulatory strategies to ameliorate the problem. Task 4 is to conduct analyses of the social, economic, and other impacts of the strategies being considered; and Task 5 is to analyze the modes of implementation for selected strategies, and to derive recommendations for action.

I will just quickly scan now what is in the paper. In Task 1, some comments are made on the development of a framework for analysis. The general structure depicted is one where there are four thematic areas for investigation, emitter activities, transformation in the environment, receptor effects, and control. Of these four thematic areas, emitter activities would involve the identification of noise-emitting activities, their socio-economic functions, determination of times and quantities of products used, determination of noise emission rates over space and time, determination of economic and trade significanec.

And we have then gone on to identify the various major activities and actors in these processes. The activities I won't bother repeating; they are listed here. And I am sure there is a lot of consensus on the major noise-emitting activities.

The emitting activity actors, we feel, can generally be depicted in the following cluster: the designer and manufacturer of the product or its components, the retailer, the purchaser-user, his employees, the provider of his facilities for use. And this can be broken down or specialized to a greater extent.

The second thematic area for investigation would be the transformation of noise in the environment, and here we have simply listed—although none of us are noise experts—we have simply listed what we feel are major considerations affecting noise in the environment: termination of physical processes, dispersion, persistence, accumulation and concentrations, time lags, etc., determination of natural modification mechanisms, weather, meteorological conditions, and so on, as well as manmade modification mechanisms, such as road surface, and densities, and shapes of structures, etc.

We have then gone on to depict the actors in this context. In the paper we discuss the third thematic area for investigation of receptor effects, and I should say that this third and very troublesome area will inevitably stress physical and mental health effects on the human receptor since this is fundamentally the primary concern, and also the aspect with most data available from psychoacoustics and health research.

Since receptor effects are the output quantities essential to decision-making, we feel the total spectrum of receptor effects—economic, social, health, and so on—must be considered in the analysis, and we have tried, as a beginning effort, to structure these environmental effects.

The fourth thematic area of control to be developed would involve identification of existing legislative, judicial, and regulatory control mechanisms, and their functions regarding noise pollution. At the local level, these existing controls include nuisance, trespass, and other actions in tort and common law, unconstitutional takings of property, police power, zoning, land use, and noise abatement ordinances, and building codes. At the State level: State regulation of transportation, structures, recreation, and other noise-emitting activities, public health agencies, airport, and other transportation promotion authorities. And we have listed several others here for the record.

At the Federal level, there is a wide variety of legislation, some of which peripherally concerns noise abatement and control, some of which is a direct confrontation to discrete sources of noise.

Finally, de facto considerations, citizen pressures on political and regulatory bodies must be considered. They are obviously reflecting objectives of values which are not reflected in some of the legislation or existing patterns of regulatory activity.

As the second task in this sequence, we feel—the second task is essentially a procedural one of making decisions and/or assumptions about the specific nature of the noise-emitting activities that have been chosen for study. And the articulation of this assumption-making process and its result ought to be derived from the framework of Task 1. This is an on-going process, as I noted earlier, and the assembly of the information and assumptions which constitutes this procedural task provide the foundation upon the subsequent decisions as to strategies to be selected, impact analyses of the strategies and how to implement the particular strategies.

We have considered only 4 of probably many more issues which will have to eventually be presented: dispersion characteristics, persistence characteristics, effects on receptor environment, and detrimental receptor effects.

Admittedly this is a simplistic beginning, but it is only a beginning.

Following this task, we—following the derivation of assumptions as to receptor effects—and I should add that the assumption-making process has to be based, we feel, on the aggregation of emitting activities in realistic contexts, human contexts—wilderness, rural, suburban, urban office, urban industrial, urban home. Following the derivation of these assumptions, based on the aggregated emitting activities, we will have to disaggregate these selected patterns into major noise-emitting component activities, into the individual activities themselves, and then conduct analyses on the individual activities.

Now, we feel one would be in a position to evaluate a number of technical, economic, and legal strategies in four different contexts: in the context of product or component manufacture and sale; in the context of product application and use; in the context of working transformations or changes on the environment; and in the context of the receptor and his own environment, his own personal environment.

Within each context a variety of methods could be employed in suitable combinations or strategies in relation to the actor's present. And we have then gone on to repeat, to some extent, the actors who are present in each of these four contexts and who could be the foci for control or regulation.

Also we have tried to depict the basic technical and economic strategies to be considered for each noise-emitting activity to be studied in these four sectors or contexts. I won't bother repeating them in the interest of time.

The strategies which eventually crystallize out of this process can reasonably be expected—should be expected to be technically available and effective. However, each strategy will bear with it a number of social, political, economic, and other impacts of broad significance. These various impacts should be traced out for each strategy under consideration, and the subsequent task would then deal with these impact analyses.

Impact analyses, Task 4, we feel are the prerequisite for any balanced strategy for decision-making and analysis to come forth from EPA, and these impact analyses would encompass the entire spectrum of impacts, negative as well as positive. In other words, in due consideration of all aspects.

The impact analyses would consist of two important steps: the structuring of the impacts—and we have depicted a structure here which is again a preliminary beginning; and the second step would be the tracing out of the impacts due to each strategy or combination of strategies which is being considered.

Among the impact types, of course, are impacts on ecosystem, including wildlife, impact on human health, impacts on income, impacts on recreation, esthetics, cultural and social opportunities, and finally an impact on natural resource depletion. Alternative strategies may involve alternative resources, and the depletion problem is one which should be considered.

The relating of strategies to impacts can be accomplished, we feel, to the degree of specialization that would be necessary for particular decision-making, and I won't go into any detailed explanation of the diagrams that we have here.

Finally, in our final task, to consider the implementation of alternative strategies, this would involve a determination of goals and policies relating to noise in the environment, a determination of control structures relating to noise. The control units and their functions could then be related to noise-emitting activities and actors and receptors, etc. on matrices to be developed.

Following this, an analysis of substantive and procedural aspects of national controls and State level controls—and here, I should add, there are many minor nitty-gritty problems for EPA to confront. For example, clarification of the lead Federal agency for projects subject to national Environmental Policy Act Statements where noise is an important consideration. This has not yet been clarified in the Boston area with the Logan Airport situation, for example. The Corps of Engineers has functioned as the lead agency officially when the problem is clearly noise and not dredge and fill permits.

Finally, determination of those international linkages that should be considered. And, in conclusion, I should simply say that the development of a coherent analytical process to collect and order and integrate the data would be of great utility in a sense that it would incorporate multiple values and perspectives and information from multiple sources, and facilitate the collection of data. The articulation of this process I have spoken about.

The use of the process may enable EPA to systematically achieve noise control and abatement goals in full consideration of these numerous variables.

Dr. **Meyer.** Professor Baram, let me thank you for an excellent summarization of a long paper which contains a wealth of information of considerable value. You did a magnificent job of condensing it into a very useful brief, and I want to assure you we are going to study this in EPA quite extensively. And Dr. von Gierke made the observation to me that there are some very significant considerations particularly in this Task 4—the broad scope of total impact analysis.

I would like to ask Dr. Fidell if he has any comments.

Dr. **Fidell.** No. I guess I would view this more as not testimony of the psychological and physiological effects, but it is a plan for the organization of EPA's activities rather than as a statement of psychological and physiological effects, and I don't feel that I have any special competence to comment on it.

Dr. **Baram.** Well, this, I think, is just really being suggested as a decision-making process, not for any organizational purposes but really just as a decision-making process to be considered and discussed and perhaps modified.

Dr. **Meyer.** It is sort of a synthesis of what you do after you take into account the psychological and physiological effects of noise on man.

Dr. **Fidlel.** Well, I have no professional opinion about it.

Dr. **Meyer.** Do you—Milt?

Dr. **Whitcomb.** Well, I just wanted to comment that I am distressed that you, first of all, had to summarize the paper; and secondly that it perhaps weren't even longer. It seems there is enough meat in here for an hour or two of presentation, and I really don't feel competent to ask questions even at this point.

I am thumbing through the paper rapidly. I notice a lot of things that were interesting, but I don't feel really able to comment at this point.

Dr. **Meyer.** Well, in conclusion, I will say that this paper is one that is going to be a subject of considerable study by EPA and its staff because it does outline an approach that we must consider, and I appreciate very much the effort that has gone into it.

Dr. **Baram.** Thank you.

Dr. **Meyer.** And we will be expecting some further communications with you, Dr. Baram, on this particular subject area.

# OUTLINE FOR A SYSTEMATIC APPROACH TO NOISE ABATEMENT AND CONTROL

**Professor Michael S. Baram, MIT Civil Engineering Department and Boston University Law School**
**Dr. Samuel P. Mauch, MIT Civil Engineering Department and Basler and Hoffman, Zurich**

## Introduction

### Objectives of this Outline

This outline proposes a systematic and integrated approach to the complex problem of noise pollution. The proposed approach provides a guideline for the processes of analysis and subsequent decision-making, and aims at a balanced, coherent understanding of all relevant aspects of the problem, rather than a detailed understanding of only part of the problem.

Objectives of the outline are:

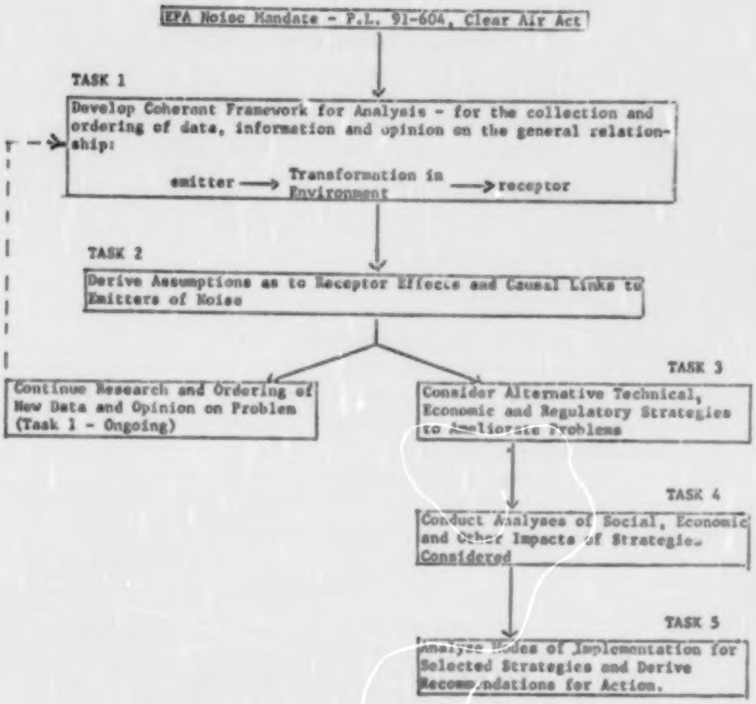
--to assist EPA towards the effective accomplishment of its noise abatement and control mandate

--to assure that objectives of the mandate are not displaced or modified by economic, political or other difficulties in the analytical and decision-making processes

--to articulate a systematic approach to the problem in its totality, which will enable technical, social, economic and legal information to be effectively collected and ordered for coherent analysis and decision-making

--to provide citizens in all sectors of society with a basic understanding of the process by which noise abatement and control can be accomplished, thereby assuring EPA accountability via informed citizen access to the process.

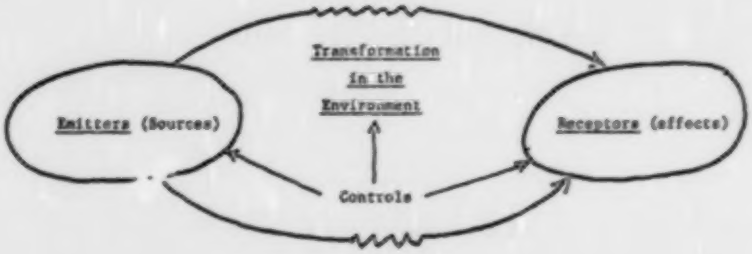
## Summary of the Outline


EPA Noise Mandate - P.L. 91-604, Clear Air Act
TASK 1
Develop Coherent Framework for Analysis - for the collection and ordering of data, information and opinion on the general relationship:
emitter
Transformation in Environment
receptor
TASK 2
Derive Assumptions as to Receptor Effects and Causal Links to Emitters of Noise
Continue Research and Ordering of New Data and Opinion on Problem (Task 1 - Ongoing)
TASK 3
Consider Alternative Technical, Economic and Regulatory Strategies to Ameliorate Problems
TASK 4
Conduct Analyses of Social, Economic and Other Impacts of Strategies Considered
TASK 5
Analyze Modes of Implementation for Selected Strategies and Derive Recommendations for Action.

## TASK 1

Framework for Analysis: To develop a coherent framework for the collection, integration, ordering and analysis of data, information and opinion.

a) General Structure - four thematic areas for investigation are identified: emitter activities, transformation in the environment, receptor effects and control.



b) Emitter Activities: Identification of activities and their socio-economic functions, determination of types and quantities of products used, determination of noise emission rates over space and time, determination of economic and trade significance.

In this step, the following activities and actors have been identified, and total activities can then be disaggregated qualitatively (decibels, etc.) and quantitatively (emission rates, etc.). This disaggregation can be done to various levels of specificity, according to specific regional parameters, population densities, etc.

Activities of major concern include:

Transportation - autos, trucks, aircraft, railroads, motorcycles, watercraft, mass transit, etc.

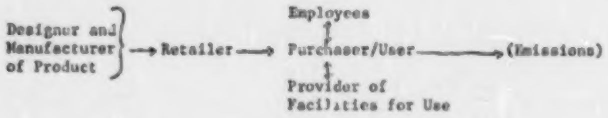
Construction
Agriculture
Resource Extraction
Industrial Processes
} usage of special equipment and facilities in process

Urban Services - trash collection, street cleaning, fire and police protection, etc.

Office and Home Activities - air conditioners, powermowers, snowblowers, etc.

Private Citizen Activities - transistor radios, snowmobiles, off-road vehicles, etc.

Actors can generally be depicted as follows:

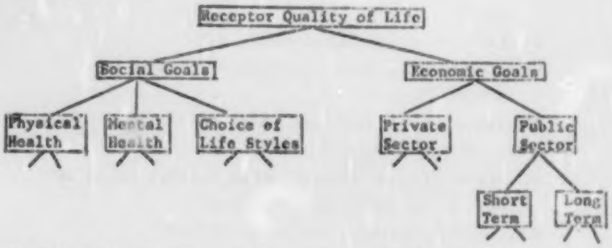

Employees
Designer and Manufacturer of Product
Retailer
Purchaser/User
(Emissions)
Provider of Facilities for Use

c) Transformation of Noise in the Environment: Determination of physical processes, dispersion, persistence, accumulation and concentrations, time lags, etc. Determination of modification mechanisms--*natural*, such as weather and meteorological conditions, trees and land configuration; *man-made*, such as road surface, densities and shapes of structures, etc.

Actors can generally be said to include urban and transportation planners, architects, construction contractors and numerous sources of funds for projects effecting change in land configuration and use; and the regulators or air, water and land use.

d) Receptor Effects: Determination of effects of noise on ecosystem, wildlife, physical and mental health, quality of life and economy of receptor. The study will inevitably stress physical and mental health effects on the human receptor, since this is an aspect of primary concern and also the aspect with most data available from psychoacoustics and health research: E.g., loss of sleep, fatigue, anger, voilence, disturbance of the fetus, diminuation of hearing acuity, disruption of cochlea, eardrum rupture and permanent loss of hearing have all been attributed to noise pollution.

Since receptor effects are the output quantities essential to decision-making, the total spectrum of receptor effects (economic, social, health, etc.) must be considered in the analysis. The following provides a general beginning for this task of structuring environmental objectives/effects:


Receptor Quality of Life
Social Goals
Economic Goals
Physical Health
Mental Health
Choice of Life Styles
Private Sector
Public Sector
Short Term
Long Term

Effects are logically related over various hierarchical levels, and ultimately connected to a single "quality of life" objective.

Actors include humans and wildlife, and the regulators of designs for homes and other constructed facilities for habitation.

e) Control: Identification of existing legislative, judicial and regulatory control mechanisms and their functions regarding noise pollution, on local, state and national levels. Determination of processes and sources of standard-setting and enforcement.

Existing Controls can be depicted as follows:

Local - Nuisance, Trespass and other actions in tort
Unconstitutional "takings"

Police Power Zoning, Land Use and Noise Abatement Ordinances
Building Codes

State - State Regulation of Transportation, Construction, Recreation and other activities
Public Health Agencies
Airport and other Transportation Promotion Authorities
Motor Vehicle Regulations
Occupational Health Regulation
Judicial Review of Administrative Decision-Making

Federal - HUD Act of 1965 re design and construction of dwelling facilities with federal funds
FAA Act of 1958 re defining of navigable airspace
FAA "Noise Type Certification Standards and Procedures" re certain aircraft
Occupational Health Legislation
Civil Aeronautics Board functions re airline route authorizations
DOT Airport and Airway Development Act of 1970 re funds for airport construction
DOT Act of 1966 and Federal Aid to Highways Act of 1968 re land use and environmental effects
National Environmental Policy Act of 1969
Clean Air Act Amendments of 1970
Judicial Review of Administrative Decision-Making

DeFacto - Citizen pressures on political and regulatory bodies

## TASK 2

## DERIVATION OF ENVIRONMENTAL ASSUMPTIONS

Classes of Environmental Assumptions: The first task has been to establish an analytical framework and procedures for securing and ordering necessary data. The second task is the procedural step of making decisions and/or assumptions about the specific nature of the noise-emitting activities chosen for study, and the articulation of this process and its results.

As has been noted earlier, Task 1 is an ongoing process of incorporating a continual flow of new data and opinions. Since Task 2 is dependent on Task 1, Task 2 (the early decision-making process) must also be considered as a open-ended process, subject to periodic revision of assumptions. Therefore, assumptions to be made are tentative and can be revised on the basis of new information developed.

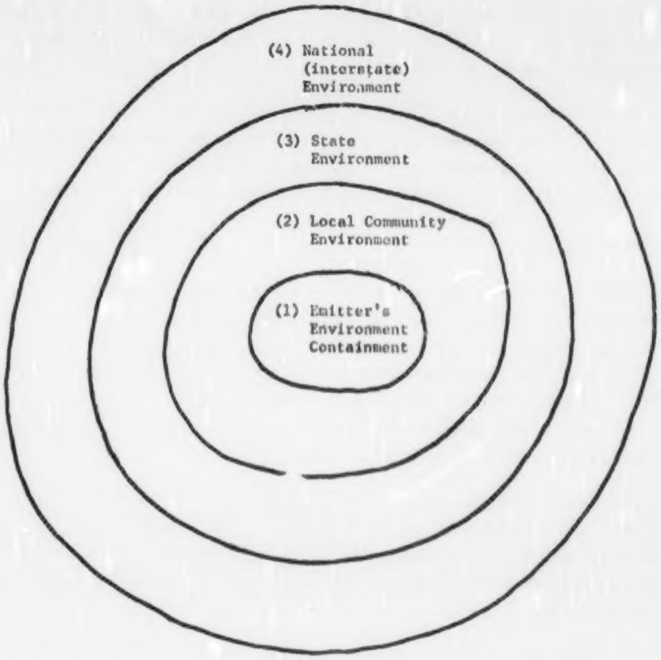
The assembly of informtion and assumptions which constitutes Task 2, provides the foundation upon which decisions concerning the need for actions to ameliorate noise-emitting conditions in the environment must be based. If the need for such action is thereby established, Task 2 will also provide the foundation upon which the investigations and decision-making of Tasks 3, 4 and 5 must be built. In these latter tasks, the political, economic and social consequences of the assumptions made in Task 2, must be confronted.

It should be emphasized that the procedure discussed herein and depicted in the introductory section insulates Task 2 decisions from being changed due to political, economic or social issues dealt with in Tasks 3, 4 and 5. The only way Task 2 decisions should be changed is through the introduction of new data and opinions in Task 1.

For the accomplishment of Task 2, the following four issues must be considered, and assumptions articulated:

a) dispersion characteristics
b) persistence characteristics
c) effects on receptor environment
d) detrimental receptor effects

a) Dispersion Characteristics: On the basis of the information provided in Task 1, one of the following assumptions about the dispersion of noise in the environment from each noise-emitting activity chosen for study is to be made. That it is:


(4) National (interstate) Environment
(3) State Environment
(2) Local Community Environment
(1) Emitter's Environment Containment

(1) Contained in Emitter's Environment: that dispersion does not normally extend beyond the boundaries of the emitter's site in which emission takes place; or

(2) Dispersion on Local Community Scale Only: that dispersion extends beyond the bounds of the emitter's site in which emission takes place, to the neighboring community and/or environment; or

(3) Dispersion Extends to a State-Wide Scale: that dispersion extends beyond neighboring community and/or environment, but not beyond state frontiers; or

(4) Dispersion Extends to Other States Also

(5) Some Combination of (1), (2), (3), and (4)

b) Persistence Characteristics: On the basis of the information provided by Task 1, and the dispersion conclusions above, the persistence-degradation characteristics of noise for each emitting activity under study are assumed to be either:

(1) consistent throughout the selected dispersion range, or

(2) variable in different subsections of the dispersion range selected . If so, assumptions must then be derived as to variability characteristics.

Following steps (a) and (b), noise-emitting activities under study must be aggregated in representative patterns, to reflect the cumulative noise conditions on receptors in several environmental contexts--e.g., wilderness, rural, suburban, urban residential, urban industrial, urban office, etc. This is necessary to develop realistic bases for deriving assumptions as to receptor effects in subsequent steps (c) and (d).

c) Receptor Effects: On the basis of the information provided by Task 1, and the conclusions thusfar made in Task 2, the cumulative emissions of noise by each of the aggregated emitting activity patterns under study are assumed to have the following unintended effects:

| | Consistent throughout Dispersion Range? | Vary in Different Subsections of Selected Dispersion Range | How |
|---|---|---|---|
| (1) On Receptor Wildlife<br>(Choose one)<br>(a) None<br>(b) Beneficial<br>(c) Detrimental<br>(d) Too Indefinite | | | |
| (2a) On Receptor Health-Physical<br>(Choose one)<br>(a) None<br>(b) Beneficial<br>(c) Detrimental<br>(d) Too Indefinite | | | |
| (2b) On Receptor Health-Mental/Physical<br>(Choose one)<br>(a) None<br>(b) Beneficial<br>(c) Detrimental<br>(d) Too Indefinite | | | |
| (3) On Receptor Economy<br>(Choose one)<br>(a) None<br>(b) Beneficial<br>(c) Detrimental<br>(d) Too Indefinite | | | |
| (4) On Receptor Social System<br>(Choose one)<br>(a) None<br>(b) Beneficial<br>(c) Detrimental<br>(d) Too Indefinite | | | |

d) Detrimental Receptor Effects: The detrimental receptor effects noted in (c) above for each/aggregated emitting activity pattern under study are assumed to have the following characteristics within the selected dispersion/persistence context:

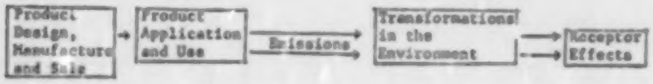
| | (Answer only for choices made in extreme left-hand column) | | | | |
|---|---|---|---|---|---|
| | | Receptor Health | | | |
| | Receptor Environment | Physical | Mental | Receptor Economy | Receptor Social System |
| (1) Time Frame<br>(choose one)<br>(a) immediate harm<br>(b) imminent harm (0 to 5 years exposure)<br>(c) future harm (5 years or more exposure) | | | | | |
| (2) Probability of Harm<br>(choose one)<br>(a) high<br>(b) very high | | | | | |
| (3) Persistence of Harm<br>(choose one)<br>(a) reversible harm<br>(b) irreversible harm | | | | | |
| (4) Scope of Harm<br>(choose one)<br>(a) affects all sectors (human and wildlife)<br>(b) affects discrete population sectors only (indicate) | | | | | |

## TASK 3

## DEVELOPMENT OF ALTERNATIVE STRATEGIES FOR AMELIORATION

Following the derivation of assumptions as to receptor effects resulting from aggregated, emitting patterns in Task 2, Task 3 can then be undertaken. The first step is to disaggregate selected patterns into major noise emitting component activities, and conduct the following analysis.

The abatement and control of specific noise-emitting activities can now be accomplished by a number of technical, economic and legal strategies. Intervention for abatement and control can occur in four basic contexts for each activity, keeping in mind the relationships of each activity within the defined aggregate patterns to receptor effect assumptions.


Product Design, Manufacture and Sale
Product Application and Use
Emissions
Transformations in the Environment
Receptor Effects

Within each context, a variety of methods can be employed in suitable combinations (strategies) in relation to the actors present. Actors can, in generic terms, be said to include the following:

Product Design, Manufacture and Sale
Design, Production, Testing and Quality Control, Marketing and Maintenance Personnel, Insurance Companies, Retailers, etc. (generally the private sector).

Product Application and Use (in a wide variety of activities noted in Part I)
Project or Activity Planners, Sources of Funds, Managers of Project or Activity Construction and Implementation, Employees, Providers of Facilities for Use, etc. (generally, both public and private sectors).

Transformation in the Environment
Urban and Transportation Planners, Architects, Construction Contractors and Numerous Sources of Funds for Planning and Projects effecting change in land configuration and use: Regulators of air, water, and land use, etc. (generally, both public and private sectors).

Receptor Effects

Humans, Wildlife, Sources of Funds and Regulators of Designs for Homes and Other Constructed Facilities for Habitation (generally, both public and private sectors).

Methods of abatement and control which relate to the actors in each context can now be depicted generally as follows:

| | Examples of Technical and Economic Strategies to be considered for each noise-emitting activity under study | Legal & Regulatory Strategies for implementation (see Task 5) |
|---|---|---|
| (a) PRODUCT DESIGN MANUFACTURE & SALE (domestic & foreign products | --product design modifications (containment, etc.)<br>--new registration of products based on submission of technical data and application of standards<br>--labelling requirements regarding usage | Legislative, regulatory, local ordinance and common law strategies at different jurisdictional levels. |
| (b) PRODUCT APPLICATION & USE | --licensing of operators<br>--regulation of use regarding duration, time of day, power levels, sites, etc.<br>--inspection and maintenance of products<br>--emission charges | |
| (c) TRANSFORMATIONS IN THE ENVIRONMENT | --regulation of land, air and water use<br>--regulation of activities in designated contexts, e.g., adjacent to airports, etc. | |
| (d) RECEPTOR EFFECTS | --reduction or modification of product consumption<br>--requirements or incentives for design and construction of habitation and other facilities (e.g. schools) | |

Out of the broad array of available methods for amelioration, only those which are applicable to the particular emitting activities under consideration, and which appear promising for success, should be selected for inclusion in a strategy. It should be noted that in general terms, several different strategies, each involving a different combination of methods, may be applicable to a particular emitting activity.

Following this, a priority ordering of the most significant emission sources can be developed. This ordering may not necessarily accord with quantities emitted, since quantities alone may not be a complete measure of significance. For example, the characteristics of emission and subsequent dispersion from a particular activity may be such that sites of sources of emission, meteorological conditions, or other parameters may take precedence over quantities of emission.

Once a priority ordering has been developed, specific and detailed "state of the art" evaluations of the various alternative strategies and of methods, as they pertain to the particular emitting activity under study, will be needed. Since little actual data exists as to the effects of the alternative strategies, "best estimates" of the costs and benefits of such strategies, as they would be applied to the priority-ordered emission sources would have to be obtained from technical, industrial, construction and other cognizant sectors. Finally, since several methods may entail new technological developments, the likelihood of such developments must be estimated in the context of the urgency of the specific problem.

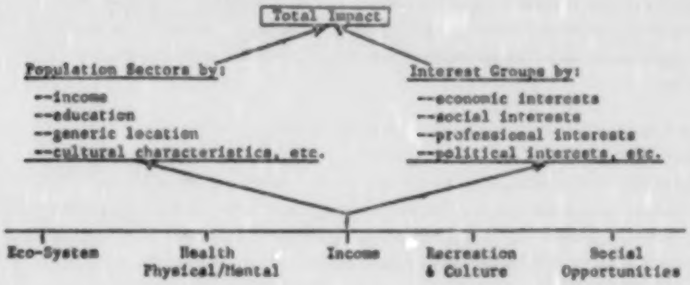
The strategies which eventually crystallize out of the above process can be reasonably expected to be technically available and effective. However, each strategy will bear with it a number of social, political, economic and other impacts of broad significance. These various impacts must be traced out for each strategy under consideration. The next part of this report deals with this task: Impact Analyses.

## TASK 4

## IMPACT ANALYSES

Proposals for balanced strategies can only come forward if they are based on impact analyses which encompass the entire spectrum of impacts, negative as well as positive, i.e. in due consideration of all aspects.

Impact analyses consist of two important steps: The first is the structuring of the impacts. Such a structure is proposed below:


Total Impact
Population Sectors by:
--income
--education
--generic location
--cultural characteristics, etc.
Interest Groups by:
--economic interests
--social interests
--professional interests
--political interests, etc.
Eco-System
Health
Physical/Mental
Income
Recreation
& Culture
Social
Opportunities

The second step involves the actual tracing out of impacts due to each strategy or combination of strategies, quantitatively where possible, and descriptively where quantification is not possible. Impacts are disaggregated on three levels:

--for different impact types (income, health, etc....)

--for different social sectors (population and interest group sectors...

--for different time horizons (present, imminent, long-term....)

Impact Types: The impact types (for selected strategies) can be somewhat more specifically developed as follows:

a) Ecosystem. Effects on the existence of organisms, wildlife, etc. and distrubence of ecological chains.

b) Human Health. Effects on physiological and psychological health.

Measures for these effects include:

mortality: number of deaths, life expectancies, etc.
morbidity: number of sick days, reduction in expected years of health, hospitalization rates, etc.
discernable genetic effects: infant mortality and illness

c) Income (Material standard of living). Here the direct and indirect contributions or effects on

--the personal income of particular population groups (industry, agriculture, retailers, etc.)
--job or skill retraining
--job security of particular population groups, labor migration
--national income (GNP)
--international trade and balance of payments
--public sector budgets (taxes, etc.)

are to considered. Here it is particularly important, however, to assess these impacts dynamically and with consideration of substitution developments through new technology and social forms. (For example, the use of substitutes for noise-emitting products in construction.)

For these impact components, monetary measures ($) are applicable.

d & e) Recreation, Aesthetics, Cultural and Social Opportunities. A broad range of effects should be traced out, including:

--Effects on recreational opportunities through adoption of strategies which entail use of land, water, air, etc.; and the consequent evolution of substitute activities which create new environmental and social demands.
--Aesthetic effects.
--Changes in cultural and social patterns resulting from impacts of particular strategies--e.g., reduction of construction or transportation mode choice, etc.
--Educational opportunities
--Professional career incentives

These impacts are largely unquantifiable at present, but even descriptive analyses will contribute to the information pool necessary for the decision makers.

f) Natural Resource Depletion. The impact of new production, land use, and other patterns resulting from specific strategies, on the long-term availability of natural resources, should also be considered.

| | | Population Group 1, e.g. Underdeveloped Countries (as Nations) | | | | | Population Group 2, e.g. Organized Interest Groups | | | | | Population Group 3, etc. | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 |
| Strategy | Method | Eco-System | Health | Income | Recreation, etc. | Opportunities | | | | | | | | | | |
| Strategy 1 | a1<br>b1<br>c1<br>: | | | | | | | | | | | | | | | |
| Strategy 2 | a2<br>b2<br>c2<br>"<br>" | | | | | | | | | | | | | | | |

Only those strategies selected in Task 3 will be analysed here as to impacts.

Strategy vs. Impact Matrix for Noise Abatement Control Efforts

## TASK 5

## IMPLEMENTATION OF ALTERNATIVE STRATEGIES

Following the assessment of alternative strategies and their impacts, as outlined in previous sections of this report, EPA will be in a position to select desired, final strategies with full consideration of their consequences, and develop policies within its mandate, as well as present recommendations for action to Congress. These policies and legislative recommendations will be designed to bring about the evolution of a national-state-local program in a coordinated sense--since they will be derived from the proposed comprehensive framework.

Such policies and legislative recommendations must be pragmatic in the sense that they would utilize to the greatest extent possible, existing modes of national-state-local environmental control and cooperation. For EPA to perform this final task, it must therefore conduct an assessment of the environmental policy implementation mechanisms which are presently or potentially available for use in the United States, determine how such mechanisms are presently linked through various legal doctrines and administrative programs, and survey the procedures and substantive concepts used by such mechanisms. This is a manageable task when conducted in the context of noise abatement and control.

This assessment of national, state and local mechanisms will reveal some deficiences which would make full implementation of recommended strategies difficult or impossible. EPA will then be able to focus on such problem areas and suggest feasible institutional and other reforms to Congress and the Executive, which will enable them to fully implement the amelioration strategies developed by EPA.

To pursue this final task, EPA must proceed with the following efforts in the limited context of desirable noise abatement and control strategies.

A. Determination of Goals and Policies Relating to Noise in the Environment, including:

(1) Goals and policies expressed at the national, state, and local levels through executive action, legislation and administrative regulation (such as the Walsh-Healey Public Contracts Act of 1969, the National Environmental Policy Act, the HUD Act of 1965, Presidential Orders, Reports of the Council on Environmental Quality, etc. See page 6 of this report for a preliminary listing.).

(2) Goals and policies which have not been formally approved, but which are believed to be significant indicators of public values--such as proposed legislation, reports of professional, expert and citizen's groups.

B. Determination of Control Structures Relating to Noise in the Environment, including:

(1) Representative bodies such as the U.S. Congress and its relevant committees, State legislatures, etc.

(2) Judicial systems

(3) Administrative units, such as HUD, DOT, EPA, Department of Interior, etc. at the national level, and counterpart state-level units.

(4) Peer groups, industrial and professional associations--which play central roles in standard-setting processes (e.g., NAS-NRC Committee on Hearing, Bioacoustics, and Biomechanics; American National Standards Institute, etc.).

(5) Crusaders and citizen's groups--which unofficially exercise considerable influence on national policies and programs

(6) Regional, state and local control units of significance.

(7) Federal and state government procurement of products and services. The control units and their functions must then be related to noise-emitting activities and actors, receptors, etc. on matrices to be developed.

C. Analysis of Substantive and Procedural Aspects of National Controls Relating to Noise in the Environment, including:

(1) Constitutional and Common Law concepts and doctrines applicable to control considerations

(2) Standards and environmental criteria which have been used in decision-making (e.g. occupational health) by agencies and courts

(3) Case studies of ad hoc occurrences of control

(4) Regulatory and enforcement policies (in this regard, clarification of the "lead" federal agency for projects subject to NEPA impact assessment reports is an important procedural consideration)

(5) Economic policies established by environmental control mechanisms, including:

(a) Effluent taxes and charges
(b) Subsidies to bring about changes in the private sector
(c) Insurance fees on product use, redeemed upon compliance with regulations and standards
(d) Price regulation of products
(e) Tariffs on the importation of products which subsequently emit noise into the environment
(f) Conservation easements and accompanying tax reductions.

D. Determination of International Linkages between Nations and International Mechanisms and their Functions, Relating to Noise in the Environment, including:

(1) Treaties

(2) Programs which extend, to some extent, national jurisdiction beyond national frontiers, such as the programs of the U.S. Agency for International Development

(3) Formal international organizations, technical advisory bodies and programs such as the UN, OECD, NATO, WHO, etc.

From the foregoing, appropriate focii for control and the nature of the controls to be imposed, can be determined for noise-emitting activities studied. As noted in section 3 of this report, controls may intervene in several basic contexts:

(1) at the source (design, production, sale, etc. of products; registration; labelling for use; evidence of compliance with standards; etc.)

(2) in the operational or emitting activity context (licensing of operators; restrictions on site, time, etc. of use, maintenance; etc.)

(3) in the environmental transformation context (siting and design of transportation and other facilities, planning and implementing of projects effecting land configuration and use, etc.)

(4) in the receptor effects context (design and construction of dwellings, offices and schools, etc.)

## CONCLUSION

The development of a coherent analytical and decision-making process, which will collect, order and integrate data, information and opinion from multiple sources is an essential first step for EPA to undertake in grappling with the technical, economic and social complexities of noise pollution.

Articulation of this process may serve to clarify objectives and dispel misconceptions; preclude expedient decision-making which arises from political and social difficulties; inform the general public and interest groups and enable them to effectively intervene in the process without inhibiting decision-making; and facilitate research and the collection of needed data and information.

Use of the process may enable EPA to systematically achieve noise control and abatement goals in full consideration of numerous variables. Finally, the experience may be of utility in grappling with other environmental problems.

(Dr. Baram's presentation follows in its entirety.)

Dr. **Meyer**. At this point, then, this hearing held in Boston, Massachusetts, by the Environmental Protection Agency on the subject of noise is hereby adjourned.

(Whereupon, the hearing adjourned at 6:20 p.m.).

(Additional statements for the record follows:)

October 26, 1971

Sir:

One of the most precious and vital qualities in the environment for the sanity and health of man is silence—or, to be more precise, the "silence" of nature. In America, this quality is also the rarest. The fact that it is so difficult, if not impossible, for the average citizen to escape from unnatural and man-made noises lessens to a significant degree the meaning of life for the human species on the north American continent.

For four years of my life, I lived in one of the most crowded—if not *the* most crowded—city in the world. Its name is Calcutta. I now live seven miles from the center of the rural town of Williamstown in the northwestern corner of Massachusetts. There is only one other house within a third of a mile of my house and there are only a dozen or so dwellings within a one-mile radius of my home. Yet when I compare my experience in Calcutta with living in a remote corner of Williamstown, I can only sadly conclude that it is sometimes easier to find silence in the crowded heart of Calcutta than it is in the remote Berkshires. This is frightening and sad because so many people's lives are diminished by the fact that they are unable to escape for any length of time from man-made noises in our land.

The primary cause of noise in this country derives from our unbalanced transportation system. We do everything in this country to blindly encourage road transportation which means an ever-increasing number of cars and trucks. These vehicles with their sounds pervade the countryside everywhere. In the last few years, the situation—particularly in rural areas—has been exacerbated by the mushrooming growth of snowmobiles and similar machines which do not serve any basic human need and which, through their excessive noise, contribute to the unhappiness of many.

The physiological and psychological effects of noise are many. Noise drains people of their energy; noise decreases human productivity; noise inhibits human communication; noise disturbs the natural habitat of other animals; and noise to the degree that it exists in America prevents man from satisfying his basic needs to hear the "sounds of silence."

I wish you, Sir, and your agency every success in alleviating the problem of noise in this country. I will be watching with interest and hopefulness to see what you do about the problem. Life is short, so that I hope you move without delay.

Samuel W. Smith
Hancock Rd.
Williamstown, Mass. 01267

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Sir:

On October 27 and 28, 1971 I attended the public hearing on noise abatement and control in Boston, Mass. At Dr. Botsford's suggestion I am submitting a written statement concerning the plight of creative people who prolonged periods of silence in order to produce. Creative persons are trained to be supersensitive! In this day and age more people have less respect for other people's privacy. With technology inventing more noisy vehicles and equipment, it is impossible for anyone to escape from noise. I wonder how many creative people, especially, find escape through drugs and alcohol. Even though noise has bothered me for years, it is just recently, since I joined the anti-noise crusade, that I have learned just how many people are actually affected, physically and mentally, by noise.

How long must creative people be at the mercy of neighbors whose only claim to fame is noise? Our next door neighbors, who live approximately 30 feet from us, are classic examples—they are young and sociable. For five years they entertained almost every night. Between 2-3 a.m. their friends would depart—always laughing and shouting; often honking horns. Now they delight in their stereo which thumps through our house at night so we can't sleep and during the daytime so I can no longer concentrate on the book I am writing and I can no longer teach my pupils. During the summertime these same neighbors blast their transistor in the back yard. They also have no conscience about revving their motorcycle mercilessly, even if it is 2:15 in the morning! ! !

For nine months one of our teenage neighbors left his house at 6:30 almost every morning, including weekends and holidays (the past few weeks it has been between 7-8 a.m.). First he "revs" either his motorcycle or his car that has a "jazzed up muffler"; then he always keeps his motor racing for 10 minutes with "revs" in between; and finally he "revs" off—he can be heard for ¼ mile or so away! He chooses to fix his noisy vehicles on Sunday mornings very early or in the evenings very late!

In our area there is an ever increasing number of household pets that are left to run during the warm summer nights. One dog starts barking and it's like a chain reaction! Often it's impossible to get a decent night's sleep. All year round some dogs are let out for a midnight run; other dogs are let out at 5 a.m.—free to bark continuously for long periods of time. Three puppies have recently joined our immediate neighborhood and some days it's absolute bedlam! I pray for a rainy day so we can get some relief!

Intermittant summer noises here include televisions on screened-in porches, power mowers, air conditioners that rattle, cat fights, and neighbors who come alive at 11 p.m.—that is the time the outdoor gathering really livens up, or someone will rearrange mental garbage cans, or fight with a spouse. Periodically from 5 a.m. on, we have low flying local aircraft. And sometime between 4-6 a.m. for a period of a half hour the local newspaper delivery man zooms around our area in his noisy car slamming doors. Electrified hard rock groups are a bit hard to take for hours on end—I'm glad the one we had in our area practiced a few blocks away and didn't practice too often!

Thieves are punished for robbing a house. Yet, there is no punishment for neighbors, who, night after night, rob others of their right to a decent night's sleep. As a result of being awakened nightly and early in the morning for so many years by sudden noises, I have been left exhausted—too tired to do my housework, much less concentrate on my book. Also, as a result of the thumping of the stereo next door, I am no longer able to teach. Over the years I have developed an excellent system for teaching rhythm to youngsters, teenagers, and adults; it has been an extremely rewarding and satisfying experience. I have always felt obligated to write a book and leave my ideas to posterity. Because of just a few noisy neighbors (the others are delightful people), I've had to give up my two fondest dreams—teaching and writing. We'd move tomorrow if we could be assured of peace and quiet somewhere else. But, in the country we'd still be plagued with motorcycles, all purpose vehicles, and goodness knows what else! Where can we escape?

I often wonder if it's worth spending all our effort, time, and money to develop the talents of our two teenage daughters. Will they inherit an even noisier future? Will they, too, become exhausted, frustrated, and be forced to give up their talents and their worthwhile contribution to society?

And so, I beg you, dear people in the office of the noise abatement and control of the EPA, to establish some standard of noise control for industrial, business, and residential areas, for certain hours of the day and night, including all noisy vehicles, equipment, and activities. Few town officials understand about the noise level standards and fewer would even want the responsibility to set the limits—they have noisy vehicles, dogs, and noisy parties, too. We place the future of creativity into your hands. Will you continue to allow noise destroy our potential?

I know that Yehudi Menuhin, the famous violinist-conductor, made a statement about noise before the United Nations not too long ago. I have written to Mr. Menuhin and to the UN. Enclosed is the xerox copy of the letter I have received from Mr. Menuhin's secretary—I will send you a copy of the motion proposed by Mr. Lutoslavsky, a composer, when I receive it. I've not yet heard from the United Nations.

Mrs. Alan Williams
47 Ellis St.
Westwood, Mass. 02090

# THE NEED FOR SOUND CONTROL IN THE HOME

Jack C. Westman, M.D.*

One of man's last outposts of privacy--his home--is being eroded, as is his natural environment, through an often unsuspected pollutant--noise. The gradual erosion of family life results from a number of personal, social and psychological factors; however, only recently an additional contributing factor - unwanted sound - has been recognized. Surprisingly, although the phrase "all I want is peace and quiet" is familiar to all, very little factual knowledge exists about the effect of noise in the home on family life.

Perhaps the neglect of household noise as a source of nervous tension in families can be explained by the general lack of information about the nature of life as it is really lived in American homes. The idea of surrounding an American family with tape recorders, cameras and observers has little natural appeal. Families have been studied in experimentally contrived environments, and an increasing amount of information is becoming available about the behavior of families through observation in their homes. Yet, the simple in concept, and technically feasible, monitoring of the physical aspects of home life has received scant attention.

A review of the literature on the auditory environment of the home was completed during the past year by Professors Bloomfield and Hay of the University of Wisconsin Department of Environmental Design. They call attention to the fact that a series of isolated observations have been carried out leading to the discovery that sound affects not only hearing, but even at levels of moderate intensity, the emotional tone of man. One of the functions of the central nervous system is to respond to loud noises with protective arousal of the body for fighting or flight. In the home, a loud voice, dishwasher, running faucet or washing machine can produce sufficient sound to mobilize bodily responses that cause narrowing of the arteries, an increase in diastolic blood pressure and a decrease in blood supply to the heart. The sound levels produced by shouting, intense arguing, a range vent fan, a garbage disposal, an electric mixer, a blender or a knife sharpener cause dilation of the pupils, drying of the mouth, loss of skin color, muscular contraction, reduction in flow of gastric juices and an increase in heart rate. (See Table 1. and Table 2.) The combination of any of these sources of noise augmented by the background sound of a television set clearly can cause or aggravate a state of heightened body arousal and general nervous tension.

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*Professor of Psychiatry, University of Wisconsin, Madison, Wisconsin

Of great significance is the fact that all of the above bodily responses to noise can be "tuned out" because of the remarkable adaptability of the human nervous system. Physician., as a result, see housewives who complain of headaches, gastrointestinal symptoms and nervous tension resulting from a general feeling of being overwhelmed by their home life. They are unaware of the fact that their symptoms are related to exposure to noise which brings to the surface submerged tensions and results in emotional outbursts, creating friction and conflict between family members.

The matter is further complicated by the fact that perceiving sound as "noise," except for sounds of very high intensity, is strongly influenced by subjective experience. For instance, sounds generated by one's self are ordinarily not perceived as noise, whereas sounds of the same intensity generated by other people, or things belonging to others, are immediately perceived as objectionable noise. The bark of the neighbor's dog is readily heard as noise, whereas one's own dog may bark without being "heard" by its owner. Age, also, clearly influences the subjective reaction to sound so that young children are oblivious to the very same sounds enjoyed by adolescents and deplored by older adults, who, as an illustration, hear the teenager's stimulating music as "noise." We find, then, that human beings possess a remarkable capacity to adapt to unpleasant sounds, a merciful fact for those of us who cannot escape the increasing levels of sound in our modern world.

Because of this adaptability, the impact of noise upon human beings is an increasing hazard, not only for the sense of hearing, but for our mental and emotional stability. Unlike the sense of vision which is easily controlled through shutting one's eyes, the sense of hearing constantly operates and is not under voluntary control. Hearing can only be protected through removing the source of sound or through occluding the ears. It is this fact that makes the control of environmental sound the only recourse available to the medical and psychiatric management of noise pollution. An awareness of the tension producing quality of noise and improving the quality of family life can help families to reduce human sound production, however, there is a limit to the extent to which this can be done. Although adults desire and seek *low sound* and *low activity* levels for pleasurable relaxation, it is a part of the nature of childhood for children to seek *high activity* and *high sound* levels in the course of their pleasure and relaxation.

The control of sound levels in homes is, therefore, an important national issue. It is a sobering fact, however, that the control of sound is a low priority item in the construction of dwellings, particularly in urban apartment complexes. Standards have been set for the control of sound intensity in industry, but, with some significant exceptions, the design of living environments has stressed appearance and salability with little or no attention to the sound qualities of the living environment. Even when the home has sufficient space to provide for high and low intensity sound zones, the area of greatest noise production and activity for the housewife - the kitchen - often is inadvertently designed to resemble a minature "boiler factory." The hard, smooth, reflecting surfaces of the tile floor, kitchen counters, cupboards, ceilings and walls frequently are devoid of sound absorbing material and, in fact, reflect and augment sound levels. It is clear, then, that construction standards should minimize sound transmission from one living unit to the other, minimize sound reflection in living areas and maximize the sound absorbency of interior finishing and furnishings. As the significance of noise production registers as one of the contributing causes of home tension, hopefully the consumer will demand an "acoustically conditioned" environment for living.

Another means of controlling home noise is through the manufacture of appliances and machines with low sound output. It is an unfortunate fact that many manufacturers have found that their products often are judged by the amount of sound they produce. Apparently whines, whirs and roars are still believed by many to be indicators of quality product performance. One manufacturer produced a quiet vaccum cleaner. To his dismay he found that housewives preferred the noise produced by competing machines. The suggestion has been made that the sound of household appliances should be well below the level of seventy decibels, the intensity of sound that activates the autonomic nervous system. Ideally the daytime home sound level in busy urban areas should not exceed fifty decibels. There is a definite need to establish standards for the sound production of household equipment.

How important noise is as a factor in the growing desire of many to escape from home life is not known at the present time. Clinical experience suggests that the inadequate management of sound in the home plays a contributing role in the breakdown of communication and the loss of pleasure in family living. Certainly, many mothers seek a working life in order to avoid the tensions generated by child rearing and to escape an unpleasant home atmosphere. This is aggravated by the acoustical generation gap between the high noise production of children and the low noise tolerance of adults. It is clear that the increasing complexity of modern living demands planning for regular opportunities for relaxation and intimacy for both children and adults. The home has traditionally provided these opportunities, however, it is becoming less able to meet this need. It is likely that human and machine generated noise plays a significant role in robbing family living of pleasure and that the most neglected aspect of architectural planning in homes is sound control.

Although further research is required to clarify the realities of auditory home environments, we have sufficient knowledge at the present time to identify noise in the home as a major public health and ecological problem. Public education to increase awareness of the hazards of noise, legislative standards to control sound levels in dwelling construction and manufactured home machinery and more definitive study of the auditory environment of the home are needed. American citizens deserve "peace and quiet" in dwellings designed to maximize comfortable family living for both adults and children.

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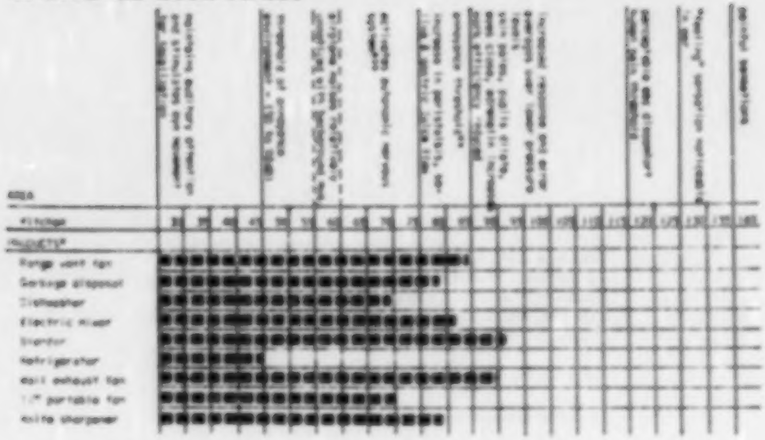
2. Burn, William, *Noise and Man*, Philadelphia, Pennsylvania: J. B. Lipincott Company, 1969.
3. Farr, Lee E., Medical Consequences of Environmental Home Noises, *Journal of the American Medical Association*, 202: 99-102, 1967.

TABLE I
Home Task Area Product Generated Noise Levels*



*Recorded at operator's or housewife's normal ear distance (dBA scale)
**Intermittent sounds
***Also occurs with loud or unexpected noises

Table 1.

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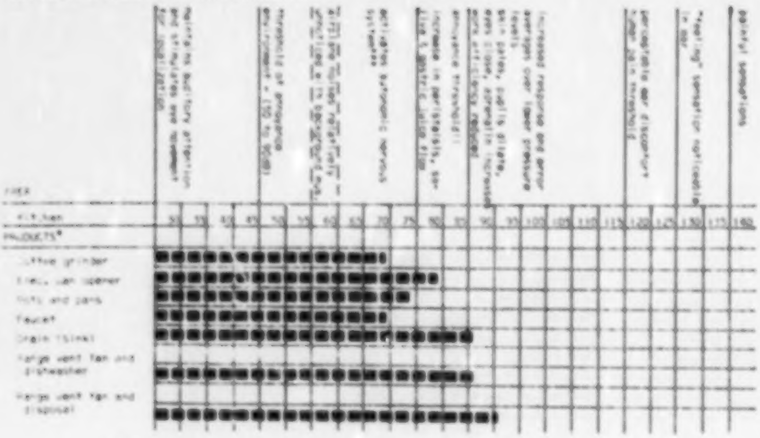
TABLE II
Home Task Area Product Generated Noise Levels*



*Recorded at operator's or housewife's normal ear distance (dBA scale)
**intermittent sounds
***also occurs with loud or unexpected noises

Table 2.

"Take the Jets Out of Here"

(an East Boston resident)

# AIRPLANE NOISE QUESTIONNAIRE RESULTS

Based on a Study

Conducted by Attorney General Robert H. Quinn's

Division of Environmental Protection

1971

## Note

This study was launched with the intent that the results would be of use within the Department of the Attorney General as a guide to efforts within the Environmental Protection Division. The awareness that aircraft noise is a problem of relatively undefined seriousness led to the study in order that any work undertaken by this office with respect to aircraft noise could be related to the experiences of those affected by it, and thereby placed in a realistic framework.

A relatively isolated, convenient and controversial noise source was chosen and responses were invited from people who indicated they were affected by the noise. The purpose of the survey was to gather a range of subjective responses from those who claimed to be affected by aircraft noise.

Recently, there have been a number of requests for copies of the study and it therefore has been made available to the public. It must be kept in mind that this report does not draw any conclusions other than those suggested by the citizens who responded and that the study was directed toward a light sampling of those individuals who felt that aircraft noise affected their lives.

## Introduction.

Attorney General Quinn's residential survey of noise at Logan Airport was distributed in March of 1971 to various neighborhood groups and interested individuals. These people, in turn, gave them to neighbors, friends and other people who are affected by aircraft and airport noise. Appendix A is a copy of the questionnaire.

A total of 515 questionnaires were distributed, and as of July 1, 1971, 142 were answered and returned. The responses came from areas around the airport, and from as far away as Quincy, Cambridge, Somerville, Wakefield, Beverly and Peabody. Appendix B constitutes a more complete list and the number of responses from each community.

The results of the survey have been divided into several sections. This introduction briefly indicates the reasons for the study and the methods and rationale employed in analyzing the results. Section one contains a discussion of noise impact on living, based on a community perception of the seriousness of the problem. In the second section some of the responses of those who answered the questionnaire are used to illustrate what community residents in the area, not scientists, engineers, technicians or aircraft or airport personnel, think are the causes, effects, and remedies of airport noise. Appendix C includes statistical evaluations of material furnished by the questionnaires.

There have been a number of studies conducted on airport noise, the results and conclusions of which differ as widely as the interests of the groups which sponsored them. The purposes of those past studies have been to objectively quantify the noise problem and to examine alternative abatement methods.

The underlying assumption made in conducting the Attorney General's study was that aircraft noise is at least as much a problem as it is perceived to be by those exposed to its effects. The study was designed to examine the subjective responses of individuals living near Logan International Airport. A state agency charged with a responsibility to protect the public's environment must at least comprehend how severe the citizenry view the problem. This modest survey attempts but to categorize the subjective reactions (and suggestions) of a small sample of citizens exposed to aircraft noise in the vicinity of the Logan facility.

Section 1. Noise Impact on the Communities.

The division of communities into four groups based on noise impact was based on information supplied by respondents. The dividing lines between the various categories are not inflexible, particularly because the number of responses from some areas was so low.

It must be made clear that even though many of the communities discussed here are small in area, some parts of them are directly under flight paths, while other parts are a mile or two away. Also, the communities are not situated so as to form narrow bands in concentric circles around the airport, but rather are irregularly shaped areas, sections of which are located closer to the airport than others. Therefore, unless one were to discuss individual responses in terms of distance from the end of a runway, distance from flight paths, and height of the planes affecting the individual, any discussion must be at least slightly general in nature. This is particularly true when dealing with subjective responses of individuals, rather than machines and scientific data.

For discussion, community classifications were made as follows:

(1) For a community to be severely affected, 80% (or more) of the respondents, from that community, must have indicated in their responses that their normal daily routine was significantly

interrupted by aircraft flights. Such interruptions would include being awakened at night, need for medication, inability to converse normally, and property damage. Another factor characterising every community determined to be severely affected, with the exception of Columbia Point, was that complaints were lodged by some respondents to Massport, state officials or local agencies.

(2) Those communities affected moderately were not subject to alleged property damage, although aircraft operations were felt to interfere with television reception and conversations, and the height of the airplanes was characterized as low.

(3) In communities upon which aircraft noise had minimal effect, one-third or less of the respondents felt that aircraft noise disturbed daily activities and the height of the planes was generally characterized as high.

(4) Residents of communities at some distance from the airport are not bothered by aircraft noise. If, in fact, planes fly nearby they are at such a height as to have a negligible effect on the living habits of people residing in those areas.

On these criteria the following classification of communities is derived:

| | |
|---|---|
| Severely Affected: | Chelsea<br>Columbia Point<br>East Boston<br>Everett<br>Revere<br>South Boston<br>Winthrop |
| Moderately Affected: | Cambridge<br>Medford<br>Roslindale |
| Minimally Affected: | Dorchester<br>Lynn<br>Peabody |
| Not Bothered: | Beverly<br>Lynnfield<br>Melrose<br>North End<br>Quincy<br>Somerville<br>Wakefield |

Section 2 Causes, Effects and Remedies Suggested by Respondents.

Comments from respondents seem to bear a direct relationship to tolerance of aircraft noise. If people were not affected, there were no comments; if minimally affected, only one or two comments; if moderately affected, some comments; and if severely affected, a large number of comments, complaints and suggestions.

Before discussing aircraft noise and its effects, a brief summary of other bothersome noises complained of might be useful as an index of what noises disturb people. Among those things complained of most often, the primary complaints were relative to automobiles; things such as blowing horns, screeching brakes, and hot-rodders. Next to automobiles, dogs barking and children playing were the greatest offenders, followed by fire engines, motorcycles, M.B.T.A. trains, trucks, drunks, Suffolk Downs, and firecrackers. One man also included his wife and two children which graphically illustrates how subjective noise perception may be.

It is important to point out that the people answering the questionnaires are not experts on noise pollution. Their responses simply indicate how they feel about aircraft noise.

The noise of airplanes passing overhead does not disturb people at a constant level. A weekend during the summer, for example, is far more disturbing than during the daylight hours in winter.

Reasons put forth for these differences include factors such as windows being open during the summer, more outdoor activities in warmer weather, and not being home during the day to hear the planes.

> EAST BOSTON - "the level of activity is intolerable during weekends."
>
> WINTHROP - "the windows are open during the summer, therefore the noise is greater."

Respondents living near the airport have developed a much greater understanding of exactly when and how the airplanes affect their lives, and are very aware of runway use and engine types. Comments made which suggest these conclusions were gained from the questionnaire where it was asked if planes landing or taking-off disturbed people more, if there was a time when they were not disturbed by airplane noise,and in the space for further comments. Many respondents complained of the VC-10 as the noisiest and named either the wind direction or runway used which most disturbed them.

> WINTHROP - "South/West winds carry noise toward my residence."
>
> REVERE - "The VC-10 is literally a teeth-clencher: one feels if the noise lasted ten seconds longer, every blood vessel in one's head would pop. The B.A.C. Rolls Royce isn't much better."
>
> WINTHROP - Not disturbed "when the runway next to my house is inactive."
>
> WINTHROP - Disturbed "when runway 9 is used."

**REVERE** - "during the shutdown of Runway 22L-4R for expansion, much of the usual noise was alleviated."

Another factor which was common to many responses was the perception of height and frequency of flights. Certainly because no accurate measurement was made, errors in judgment are to be expected, but when a respondent says planes fly 100 feet over his home and he considers that "high" is the person judging a plane's height to be 1500 feet above his roof wrong when he calls that "low"? The "high", "low", or "very low" determination served as a more accurate perception than height in feet.

**SOUTH BOSTON** - "Does one have the ability to estimate with any accuracy how many feet above a roof a plane is flying? Besides, if the noise bothers you its height is academic."

**EVERETT** - When asked how low: "low enough so that I can see the writing on the plane."

**COLUMBIA PT.** - "On some [planes] we can read the lettering."

**REVERE** - "Can read numbers [on planes] during the day. At night--do not need lights--the landing lights lite up the house."

**SOUTH BOSTON** - "Sometimes I think they [the planes] are coming into the window. I am on the 3rd floor."

Likewise, in discussing frequency of flights, if one every five minutes is "often", how can 20 per day be "very often"?

Here again, the respondent's perception of frequency is more meaningful for a subjective study.

Almost unanimously, respondents who complained of the noise feel that their complaints serve no purpose. These complaints have been directed to Massport, individual airlines, federal and state representatives and senators, the F.A.A. and the C.A.B., the Department of Transportation, aldermen, the Mayor's office, the Governor, the Attorney General, and even to Presidents Johnson and Nixon--all to no avail.

> **WINTHROP** - "In making complaints you get the feeling that you are hitting against a stone wall. Everyone is very polite and soothing, just be calm and the noise will go away. When I complained about being able to read numbers on planes F.A.A. asked a few questions but that seems to be as far as they go. Apparently despite their disclaimers they are completely in accord with Massport as far as low flying planes. And the number of maintenance, janitorial help and persons with no authority who answer the phones is apparently unlimited. Apparently no one, with the exception of Mr. King, has any authority to answer anything. For about a year now I have given up calling hoping to spare myself aggravation added to what I already have. The soothing manner of the professional public relations type doesn't soothe me."

> **REVERE** - "I have done so [complained] repeatedly since the week after we moved here and realized that the noise was worse than at our previous home. I joined the Mass. Anti Pollution & Noise Abatement Committee [sic], League of Women Voters, made countless phone calls to M.P.A., City Federal and State officials, written letters and telegrams. The noise has not abated."

Does airplane noise affect a person's health? The respondents seem to think so: "My sons, ages 7 and 15, have suffered a hearing loss" (East Boston); others say it is a mother, father, wife, husband or self who has been affected; and this "despite use of ear protectors". (Winthrop)

It is not just hearing that is allegedly affected by airplane noise and operations. The alleged noise-related health problems include physical maladies as diverse as headaches, nervousness, fright, sleeplessness, aggravation of heart conditions and irritability.

EAST BOSTON - "Headaches are common here."

CHELSEA - "Headaches severe and ears ring."

EAST BOSTON - "My hearing is partially gone. My wife is a nervous wreck, the children are high strung from tension."

SOUTH BOSTON - "If we took pills for nervousness we would be taking them all the time. No one uses ear plugs (not that I wouldn't like to)."

WINTHROP - "We all have headaches, nervousness, are irritable from constant noise."

EAST BOSTON - "Several people in the community, especially, small children, are extremely frightened by airplane noise. Babies are awakened during the day and at night. This also frightens the parents, fearing the child may be ill."

EAST BOSTON - "I manage a Little League baseball team. I can see the fright in a boy's eyes and actions when planes are landing and he's at bat. Also the High School conditions are deplorable."

EAST BOSTON - "We live in constant fear of airplane accidents due to very low flying planes directly over our house."

EAST BOSTON - "How would you like to look up from your yard and wonder if a plane is going to clear your roof?"

EAST BOSTON - "You are awakened with fright and fear as often as they come over. Have trouble falling back to sleep."

EAST BOSTON - "I have actually had company leave my home because the planes were flying so low, they were petrified. They told me, if you want to get together again, please visit us, because as long as those planes fly that low we will not visit you."

EAST BOSTON - "Myself who has to get up at 6:00 to go to work is awakened. Some nights I get about 3-4 hours sleep. I go to work very nervous from fright and lack of sleep."

SO. BOSTON - "Wakened at night. Sometimes we just bury our heads in the pillow. Have to hold our hands over our ears the noise is so terrible."

WINTHROP - "waken during summer every night."

BEACHMONT - "anyone in the house wakes up when the whole house shakes."

EAST BOSTON - "loss of sleep causes much irritability in neighbors."

REVERE - "This condition [the noise] causes me to take sleeping pills when all other efforts fail."

EAST BOSTON - "My father who was a heart patient was extremely upset about the sympathy (but no action) of the Mass. Port Authority, the Governor, and many other public officials. To be specific, one night a 747 flew over our house, my father called the M.P.A. and F.A.A. the next day. The F.A.A. and the M.P.A. were so unsympathetic and gave him no assurance or satisfaction about the incident the next morning he died of a heart attack???"

CHELSEA - "Our living environment is deteriorating because of the increasing number of jets flying over our house constantly. Our objections are not only to the noise of the jets but to the fumes from the taking-off planes. This has affected our health. The effects on people's health are not always a direct result of the aircraft noise nor does emotional strain only affect individuals - the entire family is affected."

COLUMBIA PT. - "Sometimes when I'm correcting my children for something they've done and a plane comes by, I have to yell louder which makes more mad and upset and sometimes I hit my kids."

Damage to physical and mental health is only part of the picture, though. The airplanes also allegedly cause injuries to personal property and homes.

REVERE - "When a plane flew very low in January 1970, the reverberations were such that a 60 pound antique mirror hanging on a two inch spike rode down the wall about an inch before shattering to fragments. Needless to say, I thought a plane had struck the house and almost wound up in the street wearing pajamas."

EAST BOSTON - "My ceilings all cracked beyond repair; installed block ceilings. Walls are cracked & ceiling down cellar is all down."

SO. BOSTON - "The whole house shakes awfully."

SO. BOSTON - "Building shakes and it feels planes are in my bedroom."

CHELSEA - "Dishes fall off shelf."

EAST BOSTON - "Chief engineer (from Massport) visited our home to surgey damage. Engineer admitted cracks were caused by plane vibrations . . . they [Massport] cannot assume liability for damage."

Outside sports, concerts and movies are interfered with as well as indoor activities. There is small chance of hearing anything other than engine roar when a plane passes nearby.

SO. BOSTON - They used to have concerts at Marine Park in the summertime, they were just a waste of money you couldn't hear the music with the noise of airplanes.

SO. BOSTON - Bathing in summer at Pleasure Bay is particularly annoying.

CAMBRIDGE - In summer I spend most of my free hours outside, working, eating, etc. Often these activities are interrupted - particularly conversations with other people. They just have to stop.

EAST BOSTON - "We shout to be heard until we get hoarse and then we just stop communicating."

EAST BOSTON - It's impossible to talk on the phone, or listen to the radio, or watch television without being interrupted by the noise of the planes.

EAST BOSTON - "The T.V. often loses its picture."

SO. BOSTON - Interferes a great deal with T.V. Also at times with telephoning, reading or studying.

Other people mentioned problems caused by noise such as difficulty concentrating at work and in school. Problems in these areas, as described, are not restricted to individuals, but cause disruption and deterioration of community spirit and activities.

EAST BOSTON - "I have 2 children at high school, they say noise is so unbearable teachers have to stop talking at their classes. It happens all day."

WINTHROP - "Back yards are not of much use when they are noisy. Noise makes people irritable and it is impossible to carry on a conversation with a neighbor making for isolation of people."

WINTHROP - "The spirit of the community is near the breaking point."

DORCHESTER - "If Logan is allowed to get bigger, without changes in airplanes, Dorchester will be slowly destroyed by noise."

EAST BOSTON - "Please help our community."

The eventual results of an unimproved situation such as this, where residents find the noise so intolerable must be drastic. People feel that it can only be a matter of time before more far-reaching changes destroy the residential character of the communities, and even now the homes are showing effects of noise pollution.

EAST BOSTON - "The people are all disgusted with the noise, and many are thinking of moving out but we've all lived here too long. Everyone's afraid to improve or repair their property because of the airport."

SO. BOSTON - "The City Point section is a living Hell. We will have to move out of South Boston to our regret."

EAST BOSTON - "My wife and I are thinking of picking up stakes and go on up to Maine as there seems to be no hope."

EAST BOSTON - "People have worked there [sic] whole life to have a home then it gets in the path of a runway - God help us."

EAST BOSTON - "Our children don't stay in East Boston they move as far as they can from the noise and dirt."

EAST BOSTON - "I have considered moving many times to avo the noise, but my husband is retired and h friends and family are all in this area and also our rent here is less expensive and we can't afford to pay more."

EAST BOSTON - "Have tried to sell - no buyers."

EAST BOSTON - "Have not been able to rent any of our apartments."

The residents are thus faced with problems that must be alleviated, if they cannot be solved. Partial solutions presented to lessen the impact of noise which may be taken by the individual include air conditioning, soundproofing, absenteeism and planting trees.

EVERETT - "I believe that trees help deaden the sound--so--plant more trees!"

EAST BOSTON - "We keep away from home as much as possible."

REVERE - "There were times in Beachmont that were trul depressing, especially, if one had planned on a quiet weekend at home and wound up escaping to another locale for peace."

The above suggested solutions depend on individual initiative and only serve to make the time spent at home more bearable; they do not decrease the noise.

Some people believe that Massport not only is the cause of the noise problem but intentionally aggravates it.

EAST BOSTON - "Those planes that warm up at 2 & 3 a.m. and then take off is unnecessary in my judgment. I honestly think a lot of it is put on just to make people miserable."

WINTHROP - "Wind direction is usually given as reason for keeping same pattern. This is definitely not true as when runways are closed for repairs the wind is suddenly *not* a factor."

EAST BOSTON - "Logan Airport is a discredit to East Boston, its people, and to other outlying areas. Soot from the airplane engines gathers in houses, on furniture, etc. The noise is most often unbearable. I would like to know how many employees who are higher up in position, and those of all Massport, actually live in East Boston. I doubt if many, if any do. If they did, I'm sure the situation would be different. I'm sure they would not want their families to suffer by these conditions as East Boston residents do."

The residents affected have apparently spent some time investigating possible solutions to the noise problem, and their suggestions include night curfews, use of other forms of transportation, building a second airport, expansion of Logan seaward, use of V-STOL aircraft, consolidation of flights if planes are not full, implementation of noise abatement equipment and procedures, buying property severely affected by noise, and sound-proofing of homes. It is also suggested that changed flight procedures would help- flying planes only over water, or higher, faster, or slower.

**WINTHROP** - "New noise cones on all engines."

**WINTHROP** - "Development of better aircraft."

**WINTHROP** - "Put up concrete walls and trees to lessen noise."

**BEACHMONT** - "Higher altitude landings with more sudden declines over port."

**REVERE** - "There must be an alternative to skimming the top of houses as they are now doing."

**EAST BOSTON** - "Seems the noise is loudest, when the wind is strong in a certain direction, during take-off. Possibly wind barriers or counterforce to control wind direction.

**EAST BOSTON** - "Stop Logan from expanding. Stop the proposed runway. STOP the SST. This type of progress must be curtailed for the safety of the general public, not continued for the few 'elite'."

**DORCHESTER** - "Curfew at night, making quieter engines, no big SST's and other planes."

**DORCHESTER** - "Less frequency of flights during hours of 7 pm - 11 pm."

**DORCHESTER** - "Eliminate 12 midnight to 7 a.m. flight activity."

**EAST BOSTON**- "1. A strict curfew between 12 p m. and 6 a.m
2. Minimum and maximum levels of altitude of air traffic over densely populated areas.
3. Planes should take off and land over water."

**EAST BOSTON**- "I think for East Boston, Logan Airport should be expanded toward the harbor to the islands, or use helicopters."

**EAST BOSTON**- "Have the planes go out away from East Boston towards the harbor. I hope they leave the beach for us."

EAST BOSTON - "I would say that if the airport would build their [sic] runways out to the seaway it would eliminate a lot of the noise or build an other [sic] airport away from town or cities."

EAST BOSTON - "All airports should be as far from populated areas as possible then linked by rail to connecting communities."

EAST BOSTON - "Build a second airport to relieve pressure from both Logan and surrounding communities.

EAST BOSTON - "Move airport to a non-residential area. The people of East Boston have had too much imposed on them and deserve a little peace and quiet before it becomes a ghost town."

EAST BOSTON - "They [Massport] could soundproof our homes and air condition them."

ROSLINDALE - "On departure pattern: out over ocean, gain altitude and then head in[illegible]."

COLUMBIA PT. - "Fly up higher so it won't be so loud."

SO. BOSTON - "Planes could be manufactured for more silent operation."

SO. BOSTON - "Possible governors or some type of muffler. More to the verticle [sic] take-offs."

EVERETT - "Prohibit all very heavy, large, noise aircraft at Logan at all times."

REVERE - "Consolidate flights to eliminate half empty planes."

Other responses are unequivocal or bitter.

EAST BOSTON - "Take the jets out of here."

WINTHROP - "Why don't you tear down all of East Boston, South Boston, Winthrop and turn it all over to the Airport. Then you could have real long runways. All the way to Dover and the other suburbs, saving commuting time for the travelers. A big airport in the middle of what was once a nice city is ridiculous and it should never have been allowed to expand the way it has. It is just as easy to have

> a Bostonian travel fifty miles say to Fall River as it is to have the traveler from Fall River travel to Boston. And there is sure more room in other parts of the state. And it would help the unemployment in these areas."

The attitude of the majority of noise-afflicted residents is that the airplanes and airports are necessary but solutions must be found to alleviate the noise effects. One East Boston resident made this point clearly in his commentary response.

> EAST BOSTON - "We all agree an airport is necessary but they have become an authority higher than our government, with absolutely no regard for our right to privacy and tranquillity. All we ask is the right as Americans to live as our neighbors, who I'm sure don't want a second airport in their back yard. The time has come when the rights of people come first. Only then can we win back the respect of our children; and only then can the State Government win back the respect of the people."

## Summary

The results of this survey indicate that in the opinion of those exposed the aircraft noise problem is severe in at least some areas and that it is getting worse instead of better.

Whether noise is a contributing factor to problems of health and education faced by airport-area residents, or if aircraft noise significantly affects property values is, of course, important. More important though, is the manner in which noise affects the lives, life-style and homes of these people. If an argument may reasonably be made to support the contention that aircraft noise has no ill effects on living conditions, let the argument be made to those who feel otherwise. If such an argument cannot justifiably be made then aircraft noise must be admitted to be a problem and those that cause and sponsor aircraft noise must assume responsibility for developing viable solutions.

Any "solutions" suggested in this report are those of people responding to the questionnaire. They are entitled to be heard.

☆ U.S. GOVERNMENT PRINTING OFFICE: 1972 O—[illegible]